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Global Software Development and Local
Capacity Building: A means for
improving Sustainability in Information
Systems Implementations

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Global Software Development and Local Capacity Building: A means for improving Sustainability in Information Systems Implementations

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Abstract

Information system implementations in developing countries have demonstrated a tendency to fail to persist over time. This thesis addresses this issue of sustainability by exploring how global software development and local capacity building can improve an information system's ability to endure.

Following an action research approach; I have worked as a core developer in a global software development project and participated in an effort in Vietnam for establishing a local development team. My effort included training and employment of students at the project's partner university, implementation of information systems, and practical problem-solving related to development.

Firstly, this thesis explores challenges and solutions regarding global software development and capacity building in developing countries. The case study from Vietnam demonstrates that exposing students to realistic environments in terms of requirements and feedback from users of a real-life information system encouraged practical, independent problem, which eventually increased learning. Also, combining software development with implementation support entailed comprehension of the user domain and training in requirements management as well as personal ownership and commitment to the system.

Secondly, this thesis explores challenges and solutions regarding adaptation of information systems to local contexts while maintaining global requirements. By means of experience from the global development effort I show that making solutions to local requirements as general as possible allows for including the functionality in the global solution and avoiding maintenance of local branches, and hence curb local-global tensions. Additionally, I show how flexible solutions to local requirements can benefit the global network if similar requirements are likely to emerge at other nodes.

Eventually, an IS implementation project's capability for local requirements gathering, contextual system adaptations, cultivation of learning processes, and establishment of persistent working routines has been identified in the literature as vital in order to achieve sustainability. From a pragmatic point of view; I demonstrate how and why establishing local development and implementation teams is a favourable approach for accomplishing these tasks.

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1 Introduction

This thesis addresses the subjects of global software development and capacity building, tensions between local and global requirements, and sustainability in information system implementations. The empirical part is based on my efforts in the global development of the District Health Information Software (DHIS).

1.1 *The action research project*

The author has since the spring of 2005 been involved in a global development project of a free and open source based health information system. The project is part of the Health Information Systems Programme (HISP), a global research and development network aiming at improving health information systems in developing countries.

HISP was initiated in South Africa after the fall of Apartheid in 1994. HISP has since then taken part in the process to reconstruct the health services in South Africa and has developed a district-based health information system including software, standardisation of routine health data and general approaches which is now implemented all over the country. A District Health Information Software (DHIS) application was developed in South Africa in 1997 and is still being maintained on an ongoing basis. The South African development has focused on action research, user participation and local involvement in the development of an information system aiming at strengthening local management and decentralisation in the health sector. Empowerment of local health managers through the use of local information for decision-making is among the key objectives. The relative success of the health information system in South Africa has led to an export of the DHIS and the approach to health management to several countries in Africa and Asia.

The DHIS 1.3 implementation effort in Cuba in 2003 revealed certain limitations of the existing application. Technical constraints related to the data model led to scepticism among the users. Even if the system is free and regarded as open source software, it is dependent on proprietary Microsoft technologies. This implies unacceptable expenditure for developing countries when considering the number of licenses needed in order to cover every unit in a national HIS. The system has poor networking support, which limits the ability to scale up across units. Also, the system is programmed in Visual Basic 6; a language of which Microsoft has ended free support and announced will be phased out.

The decision to start developing a new version of the DHIS was taken during the spring of 2004 at the University of Oslo (UiO), and emerged out of these circumstances. The DHIS 2 is developed under an open source software license by an open development community including nodes in Vietnam, India, and Ethiopia. The core development team consists of three Norwegian master students, including the author, located at UiO in Oslo. The system is entirely based on free and open source frameworks, implying no acquisition cost for the health departments adopting it. The system is platform independent and uses an object-relation persistence system, which implies that the system will run on any operating systems and on most database management systems.

In July 2004 HISP was contacted by the Vietnamese Ministry of Health and invited to an international open source conference called COSGov in Ho Chi Minh City (HCMC),

Vietnam. This turned out to be the start of an ongoing effort for implementing the DHIS system in Vietnam. The author has actively been a part of this project through the development effort related to DHIS 2 and a field study in HCMC from the beginning of December 2005 to the middle of February 2006. My main task for the mentioned stay was to support the collaboration with HISP's partner university in HCMC through training students. This effort was intended to enable me to select a group of competent students who eventually would get a job offer from HISP. The students accepting this offer would constitute a development and implementation team responsible for developing functionality related to local requirements and supporting the implementation of DHIS in Vietnam.

1.2 Motivation

In developing countries, preventable diseases and premature deaths still inflict a high toll. Inequity of access to basic health services affects distinct regions, communities, and social groups (Chetley et al. 2006). Under-financing of the health sector in most countries has led to quantitative and qualitative deficiencies in service delivery and to growing gaps in facility and equipment upkeep. Inefficient allocation of scarce resources and lack of coordination among key stakeholders has made duplication of efforts, overlapping responsibilities, and resource wastage common and troublesome problems.

Most countries are at some stage of health sector reform to try to provide expanded and equitable access to quality services while reducing or at least controlling the rising cost of healthcare. Health reform processes have many facets and there is no single model being adopted by all countries (PAHO 1998). However, ICTs have the potential to make a major contribution to improving access and quality of services while containing costs. Improving health involves improving public health and medical programs designed to provide elective, emergency and long-term clinical care, educating people, improving nutrition and hygiene, and providing more sanitary living conditions. These in turn ultimately involve massive social and economic changes, as many health challenges go well beyond the health sector.

The health sector has always relied on technologies. According to WHO (2004), they form the backbone of the services to prevent, diagnose and treat illness and disease. ICTs are only one category of the vast array of technologies that may be of use. Given the right policies, organisation, resources and institutions, sustainable ICTs can be powerful tools in the hands of those working to improve health (Daly 2003).

The HIV/AIDS pandemic together with the generally poor health status in Africa have emphasized the need for appropriate IST in health care for strengthening various activities such as knowledge exchange between health care managers, providers and the community, optimal allocation of resources and monitoring the roll out of the HIV/AIDS programs. Europe has a strong research base in the eHealth and there can be mutual benefits arising through co-operation between Europe and Africa (BEANISH 2006). However, given the contextual differences, for example related to infrastructure, economy, and culture, European solutions and know-how need to be sensitively reworked and appropriately translated to the African context. Furthermore, best practices, learning and workable ISTs need to be shared and further developed across African countries within a regional framework (BEANISH 2006).

Reliable information and effective communication are crucial elements in public health practices (Chetley et al. 2006). The use of appropriate technologies can increase the quality and the reach of both information and communication. On one hand, the knowledge base is about information, which enables people to produce their own health. On the other hand, social organisations help people to achieve health through health care systems and public health processes. The ability of impoverished communities to access services and demand a health sector that responds to their priorities and needs, is importantly influenced by wider information and communication processes, mediated by ICTs.

1.3 Research objectives

The previous section provides a brief introduction to my research fields, which are ICT in developing countries and global software development. This thesis is constricting these research fields to one application area; *health*, and one developing country; *Vietnam*. This is further elaborated in a main research objective and two research questions.

Research objective: *Explore how global software development and local capacity building can improve sustainability of information system implementations in developing countries.*

The main purpose for my stay in Vietnam was to establish a local, independent software development team capable of working for HISP. The intention of establishing this team was eventually to provide conditions for the DHIS information system implementation to be sustainable. I will draw on my experiences from this process and investigate to what extent establishing such teams are a favourable approach for improving sustainability. I will compare the DHIS 1 implementation processes, which was acknowledged to suffer from a lack of support personnel, with the DHIS 2 implementation process, and explore whether the presence of support and development resources is related to the information system's ability to sustain.

Research question 1: *Explore challenges and solutions regarding ICT capacity building in developing countries through participation in global software development.*

My experiences from participation within the DHIS 2 development community will form the basis for my findings related to global software development. Regarding local capacity building, I will draw on experiences obtained through the efforts for establishing a local and independent development team in Vietnam, and I will look at issues related to infrastructure, mentality, training, and communication.

Research question 2: *Explore challenges and solutions regarding adaptation of information systems to local contexts while maintaining global requirements.*

My discourse regarding local and global tensions will be based on my efforts for developing a global DHIS 2 report module that was adapted to local requirements in HCMC. I will elaborate the development approach, requirements gathering, main challenges, and adaptation to local contexts of this module.

1.4 Structure of this paper

This thesis is structured into four parts and 13 chapters. Each part opens with an introduction to the included chapters and contents. The following parts are presented:

Part 1 Literature and Background

Part 2 Methods

Part 3 Empirical study

Part 4 Discussion and Conclusion

Part 1 Literature and Background



Framework for information and communication technology in Pham Ngu Lao, Ho Chi Minh City

Chapters included in this part:

- 2 *Literature review*
- 3 *Health Information Systems Programme (HISP)*

This part presents the theoretical background of my study and accounts for the Health Information Systems Programme. Information systems are reviewed in general terms, then narrowed down to ICT and open source software in developing countries and finally to the specific application area; health information systems. Central subjects in this thesis like tensions between local and global requirements and the *networks of action* theory are also reviewed. Finally, global software development and distributed development are presented. The chapter treating HISP gives an account of the project in general before describing the DHIS 1 system, the DHIS 2 system and the HISP development network.

2 Literature review

In this chapter I will present the relevant theoretical background for this thesis. Theories and background information will be reflected in the empirical study and discussed in relation to the empirical findings.

2.1 Information Systems

This thesis maintains a social systems perspective on information systems as opposed to the traditional technology deterministic perspective. There are several theories and strategies based on social systems perspective that focuses on the introduction of information systems in organisations. Social theories like Giddens' structuration theory is applied in the field of IS to analyse the implicit change processes, and some development strategies focus on user participation and flexibility and emphasize the importance of taking the context into account.

2.1.1 Information systems as social systems

Traditional research within IT considers information systems as discrete technological artefacts, like an information processing application, which use has a predefined and direct effect on e.g. the organisation where it is implemented. In many situations and contexts this pure technological view on information systems has led to failures, and its predefined and expected effects have not always been realised in practice (Kling et al. 2000). The Social Informatics Report (ibid.) uses the term technological determinism on this perspective and explains why it can be inapplicable in information systems:

“While technological determinism can be applicable and useful in situations that are characterized by high degree of control and short time frames, it has limited value in dynamic and complex situations that unfold over longer periods of time. Technological determinism cannot adequately account for the interactions between ICT, the people who design, implement and use them, and the social and organisational contexts in which the technologies and people are embedded.” (Kling et al. 2000 p. 49-50)

Historically, the relationship between technical and social factors in working processes was first taken into account in the 1950s by English employment sociologists, and the term socio-technical systems was introduced. In the beginning of the 1970s computer experts, who until now only had discussed technical and economical issues, started to become interested in the social, organisational and psychological aspects of computer systems (Bansler 1987). Especially in Scandinavia, scholars presented theories and methods concerning the relationship between computers and humans, and information systems and organisations. Even political battles were fought by unions on how computer systems should be used in organisations. In the 70s and 80s the future prospects of computers and digital information systems were debated as mistrust and scepticism grew rapidly due to fear of mass unemployment and totalitarian societies where the government body controlled and monitored the people, as described in Orwell's 1984. Høyer (1971) presents a theory on how to fight the resistance among employees against new computer systems, and Bansler (1987) describes Høyer's theory in these terms:

“It is insufficient to look at an enterprise as a technical system as humans play a key role in the enterprise’s function, and because humans have certain needs and behaviour, that must be taken into account. [...] The system engineer has to consider these needs when he designs and implements a computer system”. (Bansler 1987 p. 90, my translation)

The concept of web models (Kling and Scacchi 1982) can be used to study information systems in a social context. Walsham explains this concept:

“Web models draw broad boundaries around the focal computer system and examine how its use depends upon a social context of complex social actions. The models define this social context by taking into account the social relations between the set of participants concerned with the information system, the infrastructure available for its support, and the previous history within the organisation of commitments made in developing and operating related computer-based technologies.” (Walsham 1993 p. 55)

He continues:

“With respect to the social relations as considered in web models, it is important to note that participants included users, system developers, the senior management of the company and any other individuals or groups who are affected by the computer-based information system.” (Walsham 1993 p. 55)

Kling et al. (2000) have produced a comprehensive report on Social Informatics in a call for more focus on the social aspects of ICT. Social Informatics refers to the interdisciplinary study of design, use and consequences of ICT that take into account their interaction with institutional and cultural contexts (ibid.). The report states that the definition of social informatics helps to emphasize a key idea:

“ICT do not exist in social or technological isolation. Their “cultural and institutional contexts” influence the ways in which they are developed, the kinds of workable configurations that are proposed, how they are implemented and used, and the range of consequences that occur for organisations and other social groupings.” (Kling et al. 2000)

2.1.2 Tensions between global and local requirements

A considerable body of literature has demonstrated empirically as well as analytically that information systems need to be situated to the local context of use. Yet for infrastructural information systems that span numerous contexts spread out globally, like the DHIS project, this is literally prohibitive. Rolland and Monteiro (2002) aim at exploring one aspect of this problem complex, namely, the negotiations around striking a balance between the need for such information infrastructures to adapt to the various local contexts they are to operate across, while simultaneously coping with this complexity by leaning toward universal solutions.

The way universal solutions, predominantly from the developed countries and economies, need, but notoriously fail to be negotiated against the needs of developing countries illustrates the problem (Braa et al. 1995). In essence, this amounts to exploring the tensions arising from two different strands of reasoning.

The former, closely aligned with readily recognizable concerns for curbing complexity, reducing risk, and maintaining control, is the argument that the only viable way to establish a global information infrastructure is to adhere to uniform, standardized solutions (Weill and Broadbent 1998). This motivation is grounded in fairly general principles and practises inspired by Fordist ideals of production (Yates 1989). Despite this, it exercises an influential role in portraying it as “obvious” that standardized solutions are beneficial (Hanseth and Monteiro 1997). Standardization enables coordination, which in turn enables the exercise of control over distance (Law 1986). This is typically aligned with the interests of management (Ciborra 2000) or developed countries (Sahay 1998).

The latter, by now well iterated and largely internalized, argues for the necessity of adapting information systems to local, situated and contextual work settings (Rolland and Monteiro 2002). There is an extensive body of both empirical and analytical arguments that emphasize local variation, contextual design, and design for situated action (ibid.). For any given information system to work, the argument goes, it has to be tailored according to the requirements of the local context of use (ibid.). This general argument for situated design has been in particular in relation to diffusion or transfer of technology from developed to less developed countries (Braa et al. 1995).

However, Rolland and Monteiro (2002) points out that the problem with the argument for situated, local context adaptation is how to deal with information systems that actually do cut across contexts. They claim that the real issue is not identifying the numerous ways in which large scale IT systems fail to fit with many, situated local contexts; rather analyzing how global, never-perfect solutions are moulded, negotiated and transformed over time into workable solutions (ibid.). Inquiring whether or not a given solution is appropriate to a situated context does not entail justice to the mentioned process as a solution does not “support” situated work – it transforms it. The key issue, then, is to make explicit the costs and benefits of these transformations and explore whether the distribution of these is reasonable.

2.2 ICT in developing countries

"The debate in the 1990s over choosing between ICT and other development imperatives has now shifted from one of tradeoffs to one of complementary." (The World Bank Group, 2003)

In this section I will present relevant literature from the field of Information and Communications Technology (ICT) in developing countries. I will start by presenting the current status on the field, outlining some of the challenges that have been identified. Then I will describe an approach that seeks to solve some of these issues, the networks of action approach. Eventually I will look into the role of OSS in developing countries.

2.2.1 Status on ICT in developing countries

All United Nations member states have pledged to meet the UN Millennium Development Goals (MDG) by the year 2015. The UN summarises the MDG:

"The MDG bind countries to do more and join forces in the fight against poverty, illiteracy, hunger, lack of education, gender inequality, child and maternal mortality, disease and

environmental degradation. The eight goal (...) calls on rich countries to relieve debt, increase aid and give poor countries fair access to their markets and their technology." (UN 2000)

The United Nations Development Programme (UNDP) recognizes that ICT can play a key role in the fight against global poverty and as an effective tool in helping to achieve the MDG. ICT opens for participation in the global markets; it promotes political accountability, improves the deliveries of basic services and enhances local development opportunities (UNDP 2005a).

There is however several challenges related to the process of applying ICT for development. The Swiss Agency for Development and Cooperation (SDC) and the Global Knowledge Partnership (GKP) presents some of these challenges:

"ICT need to be affordable for the poor, in terms of both initial outlay and on-going costs. Information received needs to be relevant, contextualised and available in the local language. Communication needs to be timely, so that information is obtained or provided neither too soon nor too late. And people require the capacities to use information." (GKP 2003)

Furthermore SDC and GKP suggest that there is a call for action on three broad areas (ibid.):

1. There is a need to integrate ICT systematically into poverty reduction strategies.
2. One needs to move beyond small pilot projects to a larger nation-wide or even region wide implementation of ICT programmes.
3. One has to continue to create new types of partnerships involving all major stakeholders – government, civil society and the private sector.

Related to these points is the issue of sustainability, the need for development efforts to last. The UN Millennium Project points out:

"Development is largely an expression of local initiative and international partnership; it cannot be sustained without local ownership and champions." (UN Millennium Project 2005)

In the next section I will present an approach that seeks to solve some of these challenges.

2.2.2 OSS in developing countries

"Consequently one major argument against the implementation of proprietary software in the public sector is the subsequent dependency on proprietary software vendors. Whenever the proprietary standards are established the necessity to follow them is given. Even in an open tender acquisition system, this requirement for compatibility with proprietary standards makes the system biased towards specific software vendors, perpetuating a dependency." (Gosh et. al. 2002)

Software development has traditionally been done following a model with formal division of labour that uses proprietary knowledge, guarded by restrictive intellectual property rights, enclosed within a corporate hierarchy, to guide and govern the process. (Weber 2003)

Software plays an increasingly important role in the global economic markets as well as in most international organisations and non-governmental organisations. The ability of a country, and the firms within it, to interact with these markets and organisations is to a large extent restricted by its ICT capacity. Weber 2003 states:

"Fairly sophisticated information technology should be thought of now as prerequisites to effectively interact with the world economy. This implies that decisions governments take about procurement, standard setting and adoption, technology investments and training is critical." (Weber 2003)

Due to the digital divide, and more specifically due to the fact that developing countries have limited budgets earmarked for information technology (Weber 2003), one of the decisions taken by many governments in the developing world is advocating the use of Free and Open Source Software (FOSS) when it is a feasible alternative to proprietary software solutions (ibid.).

Weber lists three identifiable motivations for why developing countries have chosen to embrace the use of FOSS (ibid.):

- **Independence**

Many developing countries have acknowledged that they are increasingly dependent on software suppliers located in other countries. The costs associated with implementation, licenses, and maintenance of this proprietary software is high, in addition these services do not nurture the national economy.

By advocating FOSS, local contractors can compete by price and quality on the delivery of support and maintenance, generating jobs and boosting the economy. Expensive licenses is no longer an issue, in addition the maintenance can be replicable without incurring large costs as the modification of source code is also free. (Weber 2003)

- **Security and autonomy**

One of the proclaimed advantages of FOSS compared to proprietary software is that of security. The main argument is that bugs are generally fewer and when a bug is identified it is fixed much faster in FOSS. In addition, FOSS assures that the software is secure as code can be inspected; governments need to rely on systems without elements controlled by third parties, possibly located outside the country, posing a threat to national security. Another benefit by introducing FOSS in critical governmental systems is that one will achieve diversity in the technical base which decreases the potential damages caused by computer attacks targeting monolithic code.

One of the responsibilities of most governments is to provide free access to public information. The use of standards and open formats instead of data tied to single providers guarantees this free access. Furthermore, to ensure permanence of this data, it is important to be free from the goodwill of single suppliers or monopoly conditions. Developing countries also feel that their influence on how proprietary software developed is very limited, FOSS promises more flexibility and allows autonomous input on software development.

- **Intellectual property rights and Productivity**

The intensified combat against software piracy has led many countries to advocate FOSS as an alternative to expensive proprietary software. Lower costs is one thing, another matter is that of ownership. By choosing FOSS tools, the possibility of utilizing and expanding the software is no longer limited by proprietary rights, the potential of the software tool is now only limited by the knowledge, learning and innovative energy of the users.

Extensive use of FOSS will form a technological infrastructure dependent on the delivery of other products and services, potentially boosting local economy. By combining inexpensive technical manpower with free software, local companies in emerging economies can get competitive advantages in both local and global markets.

2.2.3 Networks of Action

Through an extensive case study on the implementation of the Health Information System Programme (HISP) in several developing countries, Braa et al. (2004) seek to answer why so many action research projects in developing countries fail to persist over time. They identify two broad themes: (ibid.)

- **The problem of sustainability**

The challenge of making an IS work over time in a local setting, especially after donor based activity has ceased. This involves shaping and adapting the system to a specific context, cultivating learning processes, and institutionalising routines that persist over time.

- **The problem of scalability**

The challenge of spreading and successfully adapt one working solution to other sites. This does not only relate to the technical sides of scaling, but also to the processes of reproducing and translating the necessary working processes, funding, artefacts and people.

Braa et al. point out that the problem of sustainability needs to be approached by an action research perspective that identifies the importance of networks. In order to ensure sustainability, one needs to think of action research as but one element within a larger network of action (ibid.). An approach called the networks of action is described where action research is based on multiple nodes throughout a network, instead of on singular sites.

"Establishing networks creates opportunities for sharing of experience, knowledge, technology, and value between the various nodes of the experience." (Braa et al. 2004)

Many issues about IS in developing countries are common across all applications and areas. Yet, Braa et al. emphasise one aspect particular for the health care sector as the need to *scale up* in order to be sustainable. This demand is linked with the political vision of providing equity in access to health services and thus health information, and entails a requirement for replicating the local routines of information management to all corners of a district, all districts in a province, and to all provinces in a country (Braa et al. 2004). In other words; the value of the collected information is far more valuable as a means for allocation of resources when covering a national scope. The reason for discussing scalability in this connection is that

an information system's degree of usefulness is closely linked with its ability to persist over time; hence the concept of scalability can in a health care context be considered as a means for sustainability.

The networks of action approach address the issue of sustainability through vertical processes of appropriation inside the districts, provinces and country, linked together with horizontal processes of replication and spread across districts, provinces and countries (ibid.).

Some of these processes come from the generating local training and education facilities at the networked sites, making it possible to distribute experiences, knowledge and work practices both horizontally between sites, and vertically between the different institutions and governments agencies. Other processes come from generating local development and maintenance groups on all sites, enhancing IS development and design (ibid.).

Braa et al. further explains another aspect not directly linked with the networks of action approach, but rather to the action research approach in building these networks. In order to ensure a robust network, is important to nurture the heterogeneity within the network of participating actors, and then to align these actors interests with the action research project's approach and philosophy. This is done by involving a diversity of action researchers, both in the matter of type, level of involvement and interest. Another benefit coming from a strong and aligned network is the ability to provide necessary support to convince political controversies in matters of gaining access and financing in the growing network (ibid.).

A summary of the characteristics of the networks of action approach (ibid.):

- Abandon singular, one-site action research projects in favour of a network of sites.
- Generate local self-sufficient learning processes together with working mechanisms for the distribution of appropriately formatted experiences across sites in the form of vertical and horizontal flows.
- Nurture a robust, heterogeneous collection of actors likely to pursue distinct, yet similar agendas.
- Align interventions with the surrounding configurations of existing institutions, competing projects and efforts as well as everyday practices.

2.3 Health Information Systems

"Without reliable, relevant health information, health care managers and providers cannot optimally allocate resources, improve the quality of health services or address epidemics such as HIV/AIDS. (...) As health systems around the world are being restructured, the demand for sound information and the skills to manage and use information are increasing significantly. All countries need a national HMIS at least partially based on modern ICT technologies linking the various levels of the health system and addressing the information needs of policy makers, managers, health programmes, service providers, staff and increasingly patients." (WITFOR 2003)

Boerma defines an HIS:

“A combination of people, equipment and procedures organised to provide health information to health workers (and others) in a way that enables them to make informed decisions”. (Boerma 1991 p. 126)

It is interesting to notice that Boerma’s definition aligns with the social systems perspective reviewed in section 2.1.1. Another definition of an HIS is:

“A set of tools and procedures that a health program uses to collect, process, transmit and use data for monitoring, evaluation and control”. (Wilson et al. 2001)

Heywood et al. (1994) argue that it is important to look at the HIS as a tool for improving health care, and not as a goal in it self. An HIS should support and improve health care by increasing efficiency, quality and scope of the services through more efficient planning, organisations and management functions (ibid.).

Lippeveld and Sauerborn (2000) suggest that an HIS should support the following actions:

- Collection of data
- Transmission of data
- Processing of data
- Analysis of data
- Presentation of data
- Information use in planning and management

Health information systems are classified in clinical health information systems and routine health information systems. Clinical HISs are typically large and complex hospital information systems that focus on patient specific data. In this thesis I will focus on the routine HIS, which is the type that the DHIS applications can be classified under.

2.3.1 The routine health information system

The Routine Health Information Network (RHINO 2002) defines routine health information as:

“Information that is derived at regular intervals of a year or less through mechanisms designed to meet predictable information needs”. Potomac Statement (RHINO 2002 p. 2)

Examples of routine health information systems are:

- Health service statistics for routine services reporting and special program reporting like malaria, tuberculosis and HIV/AIDS
- Administrative data like revenue and costs, drugs, personnel, training, research and documentation
- Epidemiological and surveillance data
- Vital events like births, deaths and migrations

An important strength of routine HISs is that they put data directly into the hands of the decision makers at all levels of the health system. This information is especially useful in

health planning and management, as it empower practitioners and managers to identify and solve problems as they arise (ibid.).

The HIS is closely linked with the health system it supports, and as Lippeveld and Sauerborn state:

“A health information system can not exist by it self but as a functional entity within the framework of a comprehensive health system that offers integrated health services, including curative care, rehabilitative care, disease prevention and health promotion service.”
(Lippeveld and Sauerborn 2000 p. 17)

A national HIS that is used at all levels in the health system needs to represent the same hierarchical structure as the health system and support each level:

“The healthcare information system structure should permit generation of the necessary information for rational decision making at each level of the health system, each of these levels has specific functions that require specific decisions to be made”. (Lippeveld and Sauerborn 2000 p. 3)

The RHINO 2002 workshop states the following guidelines for developing such a system:

“The restructuring of routine health information systems should involve all key stakeholders in the design process. Experience suggests that systems that are designed by a team of “information experts” without adequate involvement of key stakeholders usually fail to reflect the needs and practical reality of service providers and managers and does not encourage the ownership of the system.” (RHINO 2002 p. 3)

2.3.2 Primary health care and the district health system

The concept of primary health care (PHC) was born at the WHO and UNICEF conference in Alma-Ata in 1978. The introduction of PHC marked a shift in health focus from the larger hospitals to health centres and from curative to preventive health care. The concept of PHC is explained in the Alma-Ata declaration:

“PHC is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community (...). It is the first level of contact of individuals, the family and community with the national health system bringing health care as close as possible to where people live and work (...). (Article VI Alma Ata declaration)

Several national attempts to implement a country-wide PHC approach after the Alma Ata declaration failed because the countries were too large and the tasks too complex and expensive to manage centrally (WHO 2005). This lead to the Harare Declaration which demanded intensified primary health care in a well-organised district health system. The health district were to be established as the operational unit for the identification of those who were not receiving full health care, and implementation of strategies to improve the health situation of the entire population (ibid.). Furthermore, the declaration considered the health districts as the most suitable operational unit to implement the PHC strategy.

WHO (2005) lists some characteristics of the health district system:

- A defined administrative area with a population of approximately 50 000 to 300 000.
- A segment of the national health system.
- It comprises all facilities and individuals in the district who are involved in health care of the various intervention levels, including not only governmental, but also church, charity and private health care providers.
- The vertical programmes (e.g. immunization, family planning or AIDS control) should be coordinated with the horizontal health services and integrated as far as possible, at least at the primary level.

Amonoo-Lartson et al. (1984) points out the local variety between countries and communities in terms of size, climate and resources etc. and suggest an approach on how to deal with this variation:

“Development of “bottom-up” as opposed to “top-down” planning, i.e. taking the needs, resources and opportunities in local communities as the starting point for planning health services, as opposed to planning on the basis solely of needs and policies as seen as the national level.” (Amonoo-Lartson 1984 p. 16)

2.4 Global software development

“Global software development is software work undertaken at geographically separated locations across national boundaries in a coordinated fashion involving real time (synchronous) and asynchronous interaction.” (Sahay 1998)

Globalization of innovation and markets has dramatically impacted software development. Today, more software projects are run in geographically distributed environments, and global software development is becoming a norm in the software industry. Overcoming time and distance, many organizations have distributed software development across geographies to capitalize on global resource pools, attractive cost structures, and round-the-clock development to achieve cycle-time acceleration and cater to local markets.

Utilising geographically distributed teams does not always increase efficiency; in fact the opposite is often the case. Herbsleb and Mockus (2001) indicate that time requirements for global software development are often more than double those for localized development. According to Herbsleb and Mockus, the main reasons for this relate to difficulties with communication and coordination.

Over the past decade, research and practitioner reports have revealed globally distributed software development's unique nuances, complexities, and challenges. These range from economic, technical, organizational, and cultural issues to those arising from different time zones, languages, and geographical locations. Furthermore, although a body of knowledge on global software development has been crafted over time, the art and science of organizing and managing globally distributed software development is still evolving.

2.4.1 Distributed development

For a number of years, the international workshop on Global Software Development (GSD) has highlighted the impact of distribution on communication, coordination and control within distributed development life cycle activities (Damien et al. 2003). This view is consistent with the position taken by a number of authors who have focused on one or more of these three fundamental processes to understand DD (Lings et al. 2006). A framework where the communication, coordination, and control activities are affected over a number of dimensions are well elaborated in the literature (Lings et al. 2006) and relate to temporal, geographic and socio-cultural distance.

In this framework; successful *communication* is defined as the exchange of complete and unambiguous information where the sender and receiver can reach a common understanding (Carmel and Agarwal 2001). The communication process concerns the transfer of knowledge and information between actors, and the tools used to facilitate such interaction.

Coordination is defined as “the act of integrating each task with each organisational unit so the unit contributes to the overall objective (Carmel and Agarwal 2001). The coordination process concern how this interaction makes actors independent on each other: “Two people have a coordination problem whenever they have common interests, or goals, and each person’s actions depend on the actions of the other” (Clark 1996).

Control is defined as “the process of adhering to goals, policies, standards, or quality levels” (Carmel and Agarwal 2001). The control process concerns the management and reporting mechanisms put in place to make sure a development activity is making the expected progress.

Temporal distance is a directional measure of the dislocation in time experienced by two actors wishing to interact. Temporal distance can be caused by time zone differences or time shifting work patterns. In general, low temporal distances improves opportunities for timely synchronous communication but may reduce management options (Lings et al. 2006).

Geographical distance is a directional measure of the effort required for one actor to visit another at the latter’s home site. Geographical distance is best measured in ease of relocating rather than kilometres. In general, low geographical distance offers greater scope for periods of collocated, inter-team working (Lings et al. 2006).

Socio-cultural distance is a directional measure of an actor’s comprehension of another actor’s values and normative practises. As a consequence, it is possible for actor A to be socio-culturally closer to actor B than B is to A. It is a complex dimension, involving organisational culture, national culture, language, politics, individual motivation, and work ethics. In general, low socio-cultural distance improves communication and lowers risk (Lings et al. 2006).

Process	Dimension		
	<i>Temporal distance</i>	<i>Geographical distance</i>	<i>Socio-cultural distance</i>
<i>Communication</i>	Reduced opportunities for synchronous communication, introducing delayed feedback. Improved preservation of communication.	Potential for greater proximity to market and utilization of remote skilled work forces. Increased cost and logistics for face to face meetings.	Potential for stimulating innovation and sharing best practice, but also for misunderstandings.
<i>Coordination</i>	With appropriate division of work, coordination needs can be minimized. Coordination costs typically increase with distance.	Increase in size and skills of labour pool can offer more flexible coordination planning. Reduced informal contact can lead to reduced trust and lack of critical task awareness.	Potential for learning and access to richer skill set. Inconsistency in work practices can impinge effective coordination, as can reduced cooperation through misunderstandings.
<i>Control</i>	Time zone effectiveness can be utilized to gaining efficient 24/7 work. Management of project artefacts may be subject to delays.	Difficult to convey vision and strategy. Communication changes often leave an audit trail, but can be threatened at key times.	Perceived threat from training low-cost rivals. Different perceptions of authority/hierarchy can undermine morale. Managers must adapt to local regulations.

Table 1: Framework for analyzing distributed development provided by Lings et al.

2.4.2 Strategies used in successful distributed development projects

In this section I will present strategies worked out from successful distributed development projects, presented by Lings et al. (2006). The strategies are based on the previous peer-reviewed literature, specifically focusing on case studies and field studies in distributed development.

Have a clear distribution rationale

Not all projects and not all collaboration contexts are equally amenable to distributed development. From a context perspective, offshore teams with a language in common would be favourable. When establishing a collaboration involving stakeholders with different native languages, there is a perceived increase in socio-cultural distance. For example, it has been argued that the “language factor is one of the reasons for the success of offshore IT work in countries with strong English language capabilities such as the Philippines and Singapore” (Carmel and Agarwal 2001). It may be advantageous to select for low temporal distance, unless follow-the-sun working is relevant. In any case, it is favourable that regular working time overlap between sites (Carmel and Agarwal 2001). From a project perspective, Herbsleb

and Grinter (1999) suggest that to the extent possible one should “only split the development of well-understood products or parts of products where plans, processes and interfaces are established and likely to be stable”.

Clarify all understandings

At the start of the project goals and targets should be agreed and communicated, and ensured that commitments are genuinely understood (Lings et al. 2006). The importance of documenting project goals is emphasised by Bass and Paulish (2004) who claim that “in the absence of clear direction, local cultural and personal biases are going to influence decisions. The resulting choices may not be in line with the overall goals of the project”. Ebert and DeNeve (2001) recommend defining “at a project’s beginning which teams are involved and what they will do in each location”, and ensuring that “commitments exist in written and controlled form”.

Leverage modularity

The importance of a well-partitioned architecture is stressed by Bass and Paulish (2004), who claim that “in order to facilitate work break down across multiple sites, the architecture needed to reflect the organizational structure of the project”. They state that the system need to be well-defined into components with understood dependencies for each site (ibid.). In applying this strategy, the project itself may be made to reflect the structure of the system to be built, to guarantee no tension in the light of Conway’s Law (which says that the structure of the system mirrors the structure of the organization that designed it). Herbsleb and Grinter (1999) use this idea to recommend, “To the extent possible, assign work to different sites according to the greatest possible architectural separation in a design that is as modular as possible”. Also, Distributed component development brings with it the issue of system integration and the need to avoid a “big bang” integration activity within a project (Battin et al. 2001).

Use cultural mediation

Liaisons between teams have been found to be a very effective strategy for building trust and improving communication in a project. E.g. Battin et al. (2001) found, in a GSD project in Motorola, that liaisons were a good way for overcoming socio-cultural tensions: “The liaisons provided the key link between the architecture team and the development teams, as well as providing the US management team with a face to put with the non-US centres”. Many companies have project managers or key executives who act as cultural liaisons, implying that they frequently travel between the key stakeholder sites (Lings et al. 2006). In so doing, the role is “to facilitate the cultural, linguistic, and organizational flow of communication and to bridge cultures, mediate conflicts, and resolve cultural miscommunications” (Carmel and Agarwal 2001).

Facilitate human communication

Face-to-face communication is still acknowledged to be the best in most situations, but is clearly not always practical. Hence, a number of communication strategies have been used to maintain elements of synchronous communication (Lings et al. 2006). E.g. Ebert and DeNeve (2001) recommend provision of “sufficient communication means, such as videoconferencing or shared workspaces and global software libraries” as an approach for improving human

communication within distributed projects. However, current technology often brings with it the inherent “challenge of delay due to inadequate, asynchronous communication” (Damian and Zowghi 2002).

Encourage temporary collocation

During parallel development activities, temporary collocation of people from various development nodes is used by many organisations to synchronise activity and strengthen morale and lower socio-cultural distance (Lings et al. 2006). Boland and Fitzgerald (2004) report on the use of quarterly sync-up meetings as a successful strategy for maintaining morale and motivation among team members. Damian and Zowghi (2002) recommend temporary collation as an approach for improving “awareness of users’ local working context” and for contributing to “better communication with sources of requirements through a more appropriate participation from field personnel”.

Encompass heterogeneity

It may be that homogeneity appears attractive within a distributed project, but heterogeneity is likely to be unavoidable and so should be carefully planned for. Heterogeneity may occur in methods and/or tools and/or terminology (Lings et al. 2006). Battin et al. (2001) report on the need to accommodate existing processes, to “let each team begin producing results immediately, using a process they were familiar with. If the teams had been forced into a common process, the learning curve would have impacted the delivery of the system”. A related problem concerns notations and terminology used in a project. This was experienced in the project analyzed by Battin et al. (200, p. 75): “We understood the inconsistency in notations and terminology in the beginning of the project and came up with a set of common ‘work products’ and vocabulary.” They emphasize the need for standardization in documentation at the project level to facilitate tracking in the shared project databases. Although potentially advantageous, homogeneity may not be achievable in the tools chosen for a project. For example, the same version of a tool may not be marketed and supported in all locations (Lings et al. 2006). As experienced in a project analyzed by Battin et al. (2001), “Obtaining the same version of a product from multiple sales teams proved quite difficult. While the latest version of most products was readily available in the US, the vendors were often still introducing previous versions in other countries.”

2.4.3 The strategies related to the framework

The first strategy of *having a clear distribution rationale* addresses primarily problems related to temporal and socio-cultural distance by reducing the need for communication, which in turn simplifies coordination and control.

The second strategy of *clarifying all understandings* is mainly a way of reducing potential misunderstandings and communication failures emerging as a result of different socio-cultural background.

The third strategy of *leverage modularity* is optimising the utilization of local expertise through system architecture, and thus reducing potential problems related to coordination and control.

The fourth strategy of *using cultural mediation* encourages organisations to reduce socio-cultural distance through human interaction like the use of cultural liaisons and face to face meetings.

The fifth strategy of *facilitating human communication* focuses on the communication process across all three dimensions of distance, as well as regarding it as fundamental for successful coordination and control.

The sixth strategy of *encouraging temporary collocation* addresses socio-cultural distance as it takes the cultural mediation even further, and aim at improving coordination between teams through improved communication.

The seventh strategy of *encompassing heterogeneity* addresses the coordination and control process as it aims at allowing for different work practises managed through a common method framework.

Process	Dimension		
	<i>Temporal distance</i>	<i>Geographical distance</i>	<i>Socio-cultural distance</i>
<i>Communication</i>	Have a clear distribution rationale Facilitate human communication	Use cultural mediation Facilitate human communication Encourage temporary collocation	Have a clear distribution rationale Clarify all understandings Use cultural mediation Encourage temporary collocation
<i>Coordination</i>	Have a clear distribution rationale Facilitate human communication	Leverage modularity Encourage temporary collocation Facilitate human communication	Clarify all understandings Encourage temporary collocation Encompass heterogeneity
<i>Control</i>	Have a clear distribution rationale	Leverage modularity	Clarify all understandings Encompass heterogeneity

Table 2: Positioning of strategies for DD success with the framework provided by Lings et al.

Lings et al. (2006) suggest that thinking of Table 2 as a tool for finding an optimal minimum set of strategies that will cover all of the nine DD problem areas is not advisable, since there is no guarantee that a strategy is either necessary or sufficient to overcome problems in any particular area. Rather, the mapping should be seen as a guide to which areas that may have been left out should particular strategies not have been put into practise (Lings et al. 2006). Additionally, Lings et al. state that the success of each strategy is contingent upon the particular organisational context and must be tailored to suit each specific situation.

3 Health Information Systems Programme (HISP)

3.1 HISP

After the advent of democracy in 1994, post-apartheid South Africa was left with one of the least equitable health care systems in the world. After the election in 1994, South Africa's Reconstruction and Development Program established Strategic Management Teams for the reconstruction of the health sector in all provinces. As a part of this the Strategic Management Team in the Western Cape Province proposed a pilot project to develop a district health and information system. HISP was then established in 1996 in three health districts in and around Cape Town to be a part of this pilot project. Braa and Hedberg (2002) describe the first phase of the pilot project:

“The initial focus was on identifying information needs and supporting interim district management teams. These efforts transformed into two main areas of research and implementation: (1) development of Essential Data Sets and standards for primary health care data, and (2) development of a District Health Information Software application supporting the implementation and use of such data sets.” (Braa and Hedberg 2002)

As a result of this initial effort the first essential data sets (EDS) were implemented in the Cape Metropolis, including the HISP pilot districts, and later in the whole of Western Cape in 1997 (Braa and Hedberg, 2002). In 1998 HISP released the first implementation of the District Health Information Software (DHIS), supporting the standardized health care data. This was the beginning of an ongoing HIS development effort that later led to a national roll-out in South Africa. This later evolved into HISP efforts in other countries like Mozambique, India, Vietnam, Tanzania, Ethiopia and Zanzibar.

The overall goal and motivation of HISP is to empower the poor and marginalised of the world. The means for achieving this is a modern computerised health information system intended to strengthen local health services in developing countries. The software developed (DHIS) supports local use of information. Important factors are the ability to use and analyse data disaggregated locally and the possibility to create and register local data elements and indicators. The following objectives were in mind when the software was developed (Braa and Hedberg 2002):

- Shift of control of information systems from central towards local levels, i.e. towards more equal control between central and local levels.
- Local flexibility and user orientation – it should be easy to adapt the software to local conditions.
- Support for health sector reform towards decentralisation and the development of health districts, i.e. integrating the vertical flows at district level.
- Empowerment of local management, health workers and communities.
- Horizontal flow of information and knowledge, based on the principle of free access to all anonymous, aggregated health data/information.

All of these principles emphasize decentralisation and increased access to data. Braa and Hedberg (2002) present a model that they call the *hierarchy of standards*, which illustrates

how each level maintains their own needs for information. The logic behind the model is that each level in the health hierarchy is given the flexibility to define its own set of additional standards as long as it follows the standards defined by the levels above. This way a health district is given the freedom to implement a locally adapted variant of the provincial HIS, which again is an adapted variant of the national HIS.

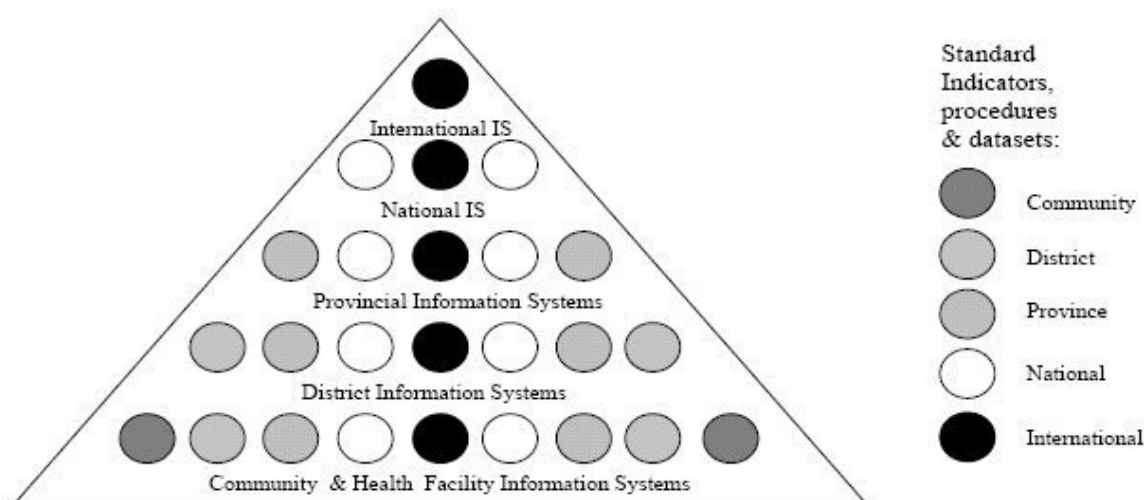


Figure 1: The hierarchy of standards.

3.2 DHIS 1

“The primary goal of the HISP research is to design, implement, and sustain HIS following a participatory approach to support local management of health care delivery and information flows in selected health facilities, districts and provinces, and its further spread within and across developing countries.” (Braa et al. 2004)

DHIS is the instrument HISP uses to achieve its primary goal. DHIS has evolved into a tool for doing planning and analysis on registered routine data, semi-permanent data (data on infrastructure and personnel), audit data and survey data. The routine data is collected at the local health facilities as well as data sets of anonymous, aggregated health data. These data sets are defined as EDSs, and represent a “set of those minimum data elements that are needed for the calculation of priority indicators” (Braa et al. 2004). HISP focuses on indicators instead of “raw” collected data. Indicators are defined and used to help monitor priority health issues, giving measures of the state of these issues (e.g. infant mortality rate), instead of only providing numbers for registered cases.

The DHIS was initially (1998-1999) developed by a two-person team; one system analyst and one developer. They worked in close collaboration with the users and the rest of the HISP team, using a participatory approach with rapid prototype cycles. New versions of the software was released and distributed on a weekly or even daily basis (Braa and Hedberg, 2002). Additional developers were hired by the project between 2000 and 2001. Since then, the development was carried out primarily by one developer who has hired external help when needed. Masters students connected to the HISP network have also participated but mostly on the implementation side. Even though the core of the development has been located

in South Africa; other countries have participated, either through contributions from the individual countries or by features driven by requirements voiced by HISP teams in other countries.

DHIS is developed in a Microsoft Access DB and Visual Basic environment. For analysis purposes the MS Office Suite has been an invaluable supplement, with Excel's pivot table functionality as arguably one of the most important tools for the health managers. The software has been packaged and bundled using the InstallShield software from Macrovision. InstallShield is proprietary and expensive software, and the availability has therefore been limited for the HISP teams. DHIS has been traditionally packaged and made ready for installation by the team in South Africa, and then distributed to the different nodes in the HISP network through the regular HISP channels. The DHIS 1.4 version has been available for download at HISP's official web site. Because of the nature of Access DB and Visual Basic applications, the software's source code is bundled with the application, available for any user that wishes to view or modify it. This task can be performed through Access, but will only affect the local installation of the application. Any changes that should be propagated to other installations must therefore go through the South African team, which is capable of integrating the changes and repackaging the application for further deployment to other sites.

3.3 DHIS 2

A DHIS 1.3 implementation effort in Cuba in 2003 revealed certain limitations of the existing application. Criticism of the state of the current DHIS version emerged from a number of central persons within the HISP network (Nordal 2006), which triggered discussions of key issues related to the software:

- DHIS was not web-enabled, and the technologies that it was built on made it practically impossible to change it. Integration between users is constrained by manual routines as import and export of data is performed by exporting to file, which later is sent by e-mail or regular mail to other users. This limited the system's ability to scale up across districts.
- The dependence on a proprietary Microsoft framework implied unacceptable expenditure for developing countries when considering the number of licenses needed for covering every unit in a national HIS.
- DHIS was a result of a lengthy prototyping approach, where new layers of functionality have been added to the existing layers, creating an overly complex data model. It was argued that a system design based on modularisation and three-tier architecture would be critical for further maintenance and development.
- The DHIS 1 systems are programmed in Visual Basic 6; a language of which Microsoft has ended free support and announced will be phased out. This implied that looking at other technical alternatives more suitable for continued evolution and development of DHIS was necessary.

The decision to start developing a completely new version named DHIS 2 emerged out of these circumstances. The decision was taken during the spring of 2004 at the University of Oslo (UiO), and implied that HISP hired a researcher to start working full time with the

project. Another PhD student joined the project shortly after and together they started an extensive review of potential technologies and frameworks (Nordal 2006). Previous versions of DHIS dictated the functional requirements of the new version and acted as a requirement specification. Additionally, two new technical requirements were considered as vital:

Firstly, the system needed to be platform independent and able to run on most relational database management systems. Even if the DHIS 1 systems were regarded as free and open source software, they were still dependent on a proprietary and expensive Microsoft framework. By allowing for platform and database independence; users would be able to run the system in a free and open source framework, e.g. on the Linux operating system and the PostgreSQL database system. This would imply no acquisition cost at all for health departments adopting the system. The DHIS 2 license is presented in Appendix B.

Secondly, feasibility for integrating both web-based and desktop modules in the application suite was considered as important. The system would basically be web-based, allowing for neat user interfaces and scalability, as the system could run on a remote server and be accessed through a web browser. Still, modules related to Geographic Information Systems (GIS), spreadsheets and advanced analysis would necessarily have to be desktop based since this type of functionality is complicated to provide purely through a web interface. Also, integration with desktop applications like Excel with its pivot tables and OpenOffice would be vital in order to achieve this.

J2EE was selected as development platform in order to meet the goal related to platform independence. Also, J2EE is an industry standard for developing scalable server-side applications, and provides services which make it highly suitable for web application development. The development frameworks and tools selected during the technology review were merely free and open source based. A decision to include an object relation persistence layer in the system architecture was made to achieve the goal of enabling the system to be run on top of a number of different database systems.

With regards to development model, DHIS 2 is being developed in a rapid prototype fashion through close collaboration with users, researchers and health professionals. While most of the development of DHIS 1 is done by a hired team of professional developers, DHIS 2 is primarily being developed by students and researchers. The requirement specification was to a large extent provided through DHIS 1, implying less need for user participation and prototyping.

3.4 Software development network

During the DHIS 1 implementation processes, HISP has put a lot of effort into establishing technical capacity at the different sites in the network. A similar strategy was planned for DHIS 2. While the capacity building efforts for DHIS 1.3 was primarily focused on use and software administration; emphasis in the DHIS 2 project is put on establishment of local software development teams.

The amount of development competence needed for stakeholders in order to contribute to the development is significantly less regarding DHIS 1 compared to DHIS 2. The Access and VB6 development platform is characterised by drag-and-drop functionality and relatively simple programming syntax. This enabled some of the stakeholders with general computer

skills to make small modifications and expansions to the software. As with DHIS 2; the complex, comprehensive and less intuitive Java frameworks and programming language being used has increased the technical gap between users and developers. This implies that more effort has to be put into training of technical personnel in order to achieve contributions to the software.

With project coordination from Norway, the first global DHIS development nodes were established in Vietnam and India in 2005. By sending Norwegian developers to these sites in order to train and integrate the local teams into the global network, HISP is aiming at establishing a global development team for DHIS 2. These teams are intended to be a part of the general development effort and make contributions to the global software, in addition to develop context-sensitive functionality to cover local needs. The local teams are also intended to be able to support implementation efforts and need for local adaptations of the software.

Part 2 Methods



Discussions and negotiations with the Vietcong 20 feet below surface in Cu-Chi district

The chapter included in this part:

4 Methods

This part accounts for the chosen methodology involving the action research and case study approach. I describe the HISP team, my methods for capturing data and possible method related limitations.

4 Methods

4.1 Research methods

As action research has been conducted in a case study; both terms will be elaborated in the next section.

4.1.1 Action Research

The research approach used in this theses falls within the framework of *action research*, which is a branch within interpretive research. Interpretive methods of research, according to Walsham (1993), start from the position that our knowledge of reality, including the domain of human action, is a social construction by human actors and that this applies equally to researchers. Thus there is no objective reality which can be discovered by researchers and replicated by others. Action research (AR) is defined by Greenwood and Levin (1998) as

“..social research carried out by a team encompassing a professional action researcher and members of an organisation or community seeking to improve their situation. AR promotes broad participation in the research process and supports action leading to a more just or satisfying situation for the stakeholders.” (Greenwood and Levin 1998)

AR is thus a process of social research where both outsiders and problem owners work together to solve problems and reach common goals. The method seeks not primarily to look for generalizations or to provide theories to be true or false, but concentrates on solving real life problems while creating knowledge. AR promotes and focuses on the interaction between the researcher and the stakeholders, contrary to conventional or critical research. Participation with the problem owners in the specific context is seen as necessary to obtain insight in matters that can not be understood when studying it from a distance. The professional researcher can also be seen as an actor who is able to loosen up tensions between the stakeholders or break up a situation they may be stuck in (Greenwood and Levin 1998). Some groups of people can have communication problems and the role as a neutral outsider may help the researcher to act as a broker and to address these problems.

“Local people, because of their history together, because of local social structures and economic relations, or simply because of decorum, often are unable to tell each other uncomfortable things that they clearly are aware of.” (ibid.)

This history of AR is not very long, with the first projects taking place during the Second World War. It was later further developed in Norway during the Industrial Democracy Project, and so the notion of democracy stands strongly in AR. With researchers actively participating together with the stakeholders, the process itself gets more democratic with everyone able to contribute. AR researchers believe that everyone has the potential to analyse their own situation, contribute to the process, and add valuable knowledge and understanding to the others involved. The researchers will gain knowledge about a problem from other participants, which in turn will learn ways to deal with these problems together with the researcher. The core of this principle is democracy, since the inclusion of local problem owners as co-researchers democratizes the research process.

The broad participation and the focus on democratising the knowledge generating process can lead to many positive effects in terms of learning. Actors involved get a closer relationship to the researcher which may contribute to a more formal and open discussion, often utilizing more of the potential among the stakeholders.

AR can be classified of being either in the northern tradition or the southern tradition. While the main goal of both traditions is democratising the various organisations and people involved; southern AR relies more on community transformations through empowering disenfranchised groups and utilizing local knowledge. The adjective southern is used because it is mainly in poor third world countries that this strong emphasis on local democratisation and empowerment of the oppressed has been the driving force. The northern tradition refers to the Scandinavian countries and industrialized countries in general, and is concerned with reforming organisations through problem solving.

It is vital to consider that the relationship between the researcher and the stakeholders in an action research situation in a southern context can be influenced by bad experiences among the locals with foreign intervention, which a relatively rich western researcher easily can be identified with. Hostility, hiding of local information, feeling of obedience to the educated outsider, and lack of self confidence may be the outcome of such situations.

AR processes and its findings are often described through case studies, and involve to some degree “storytelling”. AR is context specific and creates large amount of knowledge both at local levels and for the researchers in the process that leads to actions. Case studies are appropriate to describe this, and as general laws must apply to all particular cases, detailed stories of particular cases tests the validity of general laws (Greenwood and Levin 1998).

Both qualitative and quantitative methods of all kinds can be used in AR. The current context and situation determines which method is most suitable. Still there are three elements that must be present for a process to be defined as AR, namely research, participation and action (ibid.).

4.1.2 Action Research in the field of IS

AR has gained acceptance at the same level as quantitative studies in the field of IS (Avison et al. 1999). AR has made several contributions in development of information systems, and a special issue of the prestigious paper *MIS Quarterly* named “Action Research in Information Systems” manifested a shift to qualitative methods by the mainstream of researchers.

AR projects in the field of IS may meet a complex reality, which is often severe when it comes to projects in developing countries, which is a typical setting for AR in the field of health information systems (HIS). A common problem originating from this is the failure of the action to be sustainable when the researchers leave, i.e. the action does not persist over time. This is often the result in small donor funded pilot projects focusing on action on a limited scale, like only one level of a health hierarchy or a small part of one health program out of the many that a primary health centre are responsible for (Braa et al. 2004). Outputs from such limited action research initiatives are for all practical purposes useless for the health manager, since only full coverage will help the manager in daily management and resource allocation. When there are no benefits from such pilot projects, the efforts remain

largely unsustainable (ibid.). Therefore action research IS projects, especially in developing countries, needs to scale up and cover the needs of the users.

4.1.3 Case studies

“A case study is an in-depth exploration of one situation.” (Cornford and Smithson 1996)

This exploration often needs to have a certain time span, as a snapshot of a situation at a particular moment can not capture the process of change. In a case study the researchers devote themselves to the specific situation, and the reward is a richness of data, obtained by multiple means (ibid.). A single case study can be hard to use for generalisations, but by finding other similar studies this can be addressed by developing stronger relationships for certain relationships.

Walsham (1993) denotes case studies as “interpretive”, where the various researchers may have different perceptions of a study. The purpose of there different studies is to reveal “a truth” rather than “the truth”, since a case study will be interpreted differently amongst people, and the presentation of the case will be based on the researchers perception of the phenomena described.

A frequent criticism of case study methodology is that its dependence on a single case makes it incapable of providing a generalizing conclusion. Giddens (1984) considered case methodology "microscopic" because it lacked a sufficient number of cases. He argued that the relative size of the sample independent of the number of cases being used does not transform a multiple case into a macroscopic study. The goal of the study should establish the parameters, and then should be applied to all research. In this way, even a single case could be considered acceptable, provided it met the established objective.

4.2 Research approach

In the following section I will describe the HISP team, my methods for capturing data and possible method related limitations.

4.2.1 The HISP team

The HISP team managing the development of DHIS 2 consists of two project coordinators at UiO in Norway who are PhD students at the Information Systems research group at the Department of Informatics. These coordinators are supervised by the HISP project leader located at UiO, and work in close collaboration with various HISP coordinators in the global network. DHIS 2 leadership and coordination efforts are centralized at UiO, but independent development teams have been established in the countries where DHIS 2 is being piloted.

The core DHIS 1 development competence is located in Cape Town, South Africa. The two developers in the South African team have an influential role as advisors also in the DHIS 2 project, as their legacy and extensive experience with health information systems are of great value for the youthful DHIS 2 system. After the first official release of DHIS 2, India has been the main target area for piloting the system, and thus strongly influenced the direction of

the development. The DHIS2 project is a part of the larger HISP network, and the development process has greatly benefited from the large number of human resources like medical doctors, health workers, and software developers involved in the global network.

The author joined the DHIS 2 project during the spring of 2005 in connection with a course held by HISP at UiO related to global software development. I was incorporated into the core developer group the following autumn, and have been an active developer within the project since.

4.2.2 Interviews

Cornford and Smithson (1996) list some critical interview problems:

- Getting to see people
- Getting to see the right people
- Time to prepare, travel and write-up
- Keeping interviews on the topic

Prior to my departure to Vietnam my intention was to interview several people, mainly administrators in the health and educational sector. This proved to be hard to achieve and to some degree inappropriate. Firstly, it was hard to find time to make the interviews since my interview targets all were busy people with tight schedules. My timetable was also tight as I had a heavy workload of meetings, training of students and software development. This violates the three first criteria previously mentioned, and I had to abandon the efforts to organise formal interviews. Secondly, I gained a lot of information through discussions and conversations with the actors involved in the project. It felt inappropriate to set up formal and structured interviews after having long discussions over a topic, as I often felt I had already acquired both necessary and valuable information.

Even if few formal interviews were conducted, I had numerous informative and constructive discussions with people both in the health sector and the educational sector which provided me with information and knowledge of great value on a nearly daily basis. This could sometimes be regarded as semi-structured interviews as I had prepared questions to clarify various situations. I also had social contact with administrative people and the students at the partner university after work, which gave me the opportunity to learn more about their attitudes and apprehensions regarding the project. After returning to Oslo, I made several informal interviews with the Vietnamese students in order to stay updated on the progress of the implementation process.

4.2.3 Training

During the first month of my stay I held several lectures for the students at the partner university. The main goal of these lectures was to enable the students to start contributing to the DHIS 2 development and make the beginning of the process less painful. The lectures also gave me a good impression of the student's ability to learn and apply new technology.

I also gave presentations and explanations of the functionality in DHIS 1.4 to various people in the Ministry of Health. These sessions were opportunities for getting direct feedback on the

system. This feedback was reported to the DHIS 1.4 developers, and led to considerable bug-fixes and improvements.

4.2.4 Development and participation

During my stay in Vietnam I cooperated with the students at the partner university on the development of DHIS 2. I collaborated particularly well with one of the students on the development of a global DHIS 2 report module. Working closely and taking part in problem-solving together with the students proved to be useful as it gave me great experience and knowledge regarding the challenges that goes along with the process of building an independent software development team. The close cooperation revealed interesting issues regarding infrastructure, language and communication.

I also participated in the adaptation of DHIS 1.4 to the Vietnamese conditions together with a local DHIS 1.4 expert. From this process I learned about the challenges and requirements for adapting a health information system to a new context, including translation, adjustment of user interface, and building of local databases.

4.2.5 Meetings and negotiations

During my stay in Vietnam I functioned as a prolonged arm of the HISP coordinators in Oslo, and attended several meetings as HISP's representative where the future direction of the HISP implementations process in HCMC and the collaboration with the partner university were discussed. These meetings gave me insight in the strategies behind the decision making in the HISP Vietnam project.

4.2.6 Documents and schemes

My relation to the head of faculty and the students at the partner university gave me access to report schemes and forms needed for my research. I was also given access to a database with real data from HCMC and Hue health province, which turned out to be useful regarding testing and database setup. The head of faculty was particularly interested in programming design patterns and provided me with literature that he considered relevant for the technical challenges in the DHIS 2 development process.

4.2.7 Observation

Action research is known as an approach where the researchers forsake their traditional role as observers of events (Cornford and Smithson 1996). Despite this, observation was used as a means for getting relevant information. Observing the students at the partner university during their work provided me with a lot of knowledge regarding their mentality and working routines. Also, observing the Vietnamese health workers and the local DHIS 1.4 expert during work gave me an impression of their routines and habits.

4.2.8 Possible method-related limitations

Several factors may have influenced my research. As a part of the HISP team I may have affected people through my presence as a foreign researcher. The Vietnamese students appeared to have great respect in particular for western foreigners. Within action research there is a tendency towards positive results because of the research component. The methodology may thus prove less applicable in a real-life setting where the researcher is not present (Korpela et al. 2000).

Action research is not a quantitative method for making generalizations, and I am aware of the danger of making such generalizations based on my limited research. On the contrary, Greenwood and Levin (1996) state that since general laws must apply to particular cases, particular cases test the validity of general laws.

Part 3 Empirical study



Alley-way in down-town Ho Chi Minh City illustrating the average standards of living

Chapters included in this part:

- 5 *The Vietnamese context*
- 6 *DHIS 2*
- 7 *The HISP Vietnam project*
- 8 *Global software development within the HISP network*
- 9 *Building an independent software development team in Vietnam*

Chapter 5 gives an account of the aspects of the Vietnamese context which is relevant for my study, i.e. politics, economy, health and education system and status on ICT. Chapter 6 elaborates the development frameworks and communication and coordination tools used in the DHIS 2 project, as well as basic design and key concepts related to the system. Chapter 7 treats HISP's three consecutive efforts for implementing DHIS in Vietnam. Chapter 8 describes my contribution to the DHIS 2 system and elaborates the collaboration between the Vietnamese students and me regarding the development of a global report module. Chapter 9 describes the infrastructure and conditions for software development capacity building in Vietnam. The collaboration with HISP's partner university and the eventual employment of the students are also elaborated.

5 The Vietnamese context

The following chapter will provide a background of the Vietnamese context, which is necessary in order to understand the project incidents and important when analyzing the research objectives.

5.1 *Politics and Economy*

The Socialist Republic of Vietnam is governed through a highly centralized system dominated by the Communist Party of Vietnam, which formerly was the Vietnamese Labour Party. The Socialist Republic of Vietnam exists today as a communist state. There are no legal opposition parties in Vietnam, although a number of opposition groups do exist scattered overseas among exile communities within countries such as France and the United States. These communities have supported demonstrations and civil disobedience against the government (Wikipedia A).

A new state constitution was approved in April 1992, reaffirming the central role of the Communist Party of Vietnam in politics and society, and outlining government reorganization and increased market reforms in the economy. Though Vietnam remains a one-party state, adherence to ideological orthodoxy has become less important than economic development as a national priority (Wikipedia B). This shift towards a more liberal economy started with the economic reform *Doi Moi* in 1986 where Vietnam followed the example set by China and abandoned Marxist economic planning for the introduction of market elements. This significantly improved the economy, and made Vietnam the fastest growing economy in the world between 2000 and 2002. Due to *Doi Moi*, poverty has been significantly reduced, the World Bank has calculated that in the period from 1993-2002, the percentage of poor people by World Bank's internationally comparable poverty line was reduced from 58% to 29% (UNDP 2006).

But at any rate, Vietnam's population is one of the poorest in the world. The worst conditions are among minority groups in remote and coastal districts where the extreme poverty is partly due to limited access to education and employment (UNDP 2006). But increased unemployment is also one of the problems in other parts of Vietnam, during non harvest periods the rural unemployment rate is estimated to be as high as 35%, and in urban areas people are laid off due to reorganisation in the state sector and a continuing demobilisation. Even though the economy is better now than before the reform, the great economic growth must be seen in relation to Vietnam's initially low base and the fact that the government scales down the very high inflation rate, probably to improve Vietnam's chances of being accepted as a member of WHO (Wikipedia B 2006).

5.1.1 Foreign Relations

During the Second Indochina War (1954-75), North Vietnam balanced relations with its two major allies, the Soviet Union and the People's Republic of China. By 1975, tension began to grow as Beijing increasingly viewed Vietnam as a potential Soviet instrument to encircle China. Meanwhile, Beijing's increasing support for Cambodia's Khmer Rouge sparked Vietnamese suspicions of China's motives. Vietnamese-Chinese relations deteriorated

significantly after Hanoi instituted a ban in March 1978 on private trade. Following Vietnam's invasion of Cambodia China launched a retaliatory incursion over Vietnam's northern border (Wikipedia C). Faced with severance of Chinese aid and strained international relations, Vietnam established even closer ties with the Soviet Union and its allies in the Council for Mutual Economic Assistance (COMECON). Through the 1980s, Vietnam received nearly USD 3 billion a year in economic and military aid from the Soviet Union and conducted most of its trade with the Soviet Union and other Comecon countries. However, Soviet and Eastern bloc economic aid ceased after the break-up of the Soviet Union (Wikipedia C 2006).

Vietnam did not begin to emerge from international isolation until it withdrew its troops from Cambodia in 1989. Within months of the 1991 Paris Agreements, Vietnam established diplomatic and economic relations with Association of Southeast Asian Countries (ASEAN) as well as most of the countries of Western Europe and Northeast Asia. China re-established full diplomatic ties with Vietnam in 1991, and the two countries concluded a land border demarcation agreement in 1999 (Wikipedia C 2006).

5.2 Health system

Even though the government introduced important health sector reforms through Doi Moi, the country faces major problems when it comes to health care. There is still a relatively high maternal mortality and new or re-emerging diseases such as tuberculosis, HIV/AIDS, dengue fever and Japanese encephalitis are increasing (WHO 2006).

The health services and more generally the governmental health structure is relatively decentralized in Vietnam with the province (64 in total) as the focal point. The provincial health departments are organized under the Ministry of Health, but this relationship is more related to policy, planning and professional issues than to budgets. Health budget in a province is provided by the provincial Peoples Committee (Braa 2005). The provinces are hierarchically followed by the health districts and then by health facilities or wards. Administratively the country is divided into 61 Provinces and 631 Districts. There are 803 hospitals and 10 293 commune health centres (WHO 2006). PHC data is registered daily in paper books at the ward level and then reported monthly to the health districts' statistical office. The statistical office aggregates and analyse data before it reports further up the hierarchy to the provincial level statistical office. The World Health Organization (WHO) are assisting the Vietnamese government on several programmes, and this cooperation also includes development of tools to advocate policy change (WHO 2006).

5.3 Education system

The education in Vietnam is constructed according to a fourfold scheme, i.e. infant, primary, secondary and tertiary education. The scheme follows the standards established in various countries and is historically based on the patterns provided by the French and especially Soviet systems (Stockinger 2000). The educational system in Vietnam enjoys strong support of the government. A considerable part of the state budget is allocated for educational programs, and the quota has been growing steadily in the past years (8.9 % in 1990, 15% in 2000). However, according to influential analysts, this budget can cover only one half of the money needed of education in Vietnam. National programs include amongst others the Program of Literacy, Program of Obligatory Primary Education and Program of Support for

Education in Remote and Mountainous areas. Several large-scale programs are supported by international sponsors like the World Bank, UNESCO and UNDP (Stockinger 2000).

The aims of the development of Vietnamese educational system include that of

- Full literacy (by 2000)
- Obligatory primary education (by 2000)
- Obligatory secondary education (first stage by 2010, second stage by 2020)
- Building a sufficient number of schools (by 2010)
- Renewal of the didactic equipment
- Development of the education in remote and mountainous areas
- Facilitation and encouragement of international exchanges and projects

The weak points of the primary and secondary education system are perceived by the Vietnamese authorities mainly as belonging to three categories:

The first category is difficulties related to the logical structure of school education in Vietnam. The outstanding problems of the existing school structure is about the schools remain scattered and irrationally organized, preventing a sound linkage between production and training. They schools belong to various ministries, sectors, and localities and do not follow any master plan of development, and, as result, their activities overlap considerably in many cases. The curricula lack technological updates and standards in all professional fields and remain mainly theoretical and rigid when facing the quickly changing needs of the market (Stockinger 2000).

The second category is difficulties related to poor material conditions. The material facilities of educational institutions are perceived by the authorities as remaining poor and outdated in particular in rural areas (Stockinger 2000). Libraries lack necessary and up-to-date textbooks, books and journals. A large number of schools do not have the equipment necessary for teaching hard sciences.

The third category relates to the lack of teachers and their low level of expertise. These difficulties are one of the main hindrances to the development of national education. The matter of particular concern of the authorities is the education in disadvantaged areas and among minorities. Due to geographical, historical, and other factors, the pace of socio-economic development differs considerably from one region to another. The areas around large cities enjoy much faster and sustainable economical growth than the remote and mountainous areas (Stockinger 2000). Despite the rather sparse conditions in the public education system the government has decided to charge a low tuition fee. The intention of the low fee is to make education available for the poorest part of the population.

5.4 ICT

Vietnam's socio-economic development framework assigns ICT a strategic role in accelerating Vietnam's transition to a knowledge society and integration into the global economy. For the period of 2001-2010, the Communist Party of Vietnam (PVC) has issued some national ICT goals and targets (Elmer 2002):

- To create an enabling environment for the use and development of IT in support of modernization.
- To ensure widespread and efficient use of IT in all sectors.
- To develop the national information network to reach global levels in coverage, quality and costs.
- To develop human resources to support the use and development of IT.
- To develop the IT industry as a spearhead economic sector with an increased contribution to GDP growth.

Even though there is a strong political will and leadership aiming at reaching these targets, Vietnam was in 2002 considered to be one of the least equipped countries in the world to prosper in the networked economy in terms of ICT policy, regulatory framework and telecommunications (ibid.). A main reason for the ranking is the governmental control over the telecommunications sector. This is severely restricting the use of digital opportunities to promote sustainable development and economic growth (ibid.). From 2003, 100% of Vietnam's universities, colleges, professional secondary schools and primary schools are connected to the Internet, but due to poor equipment, the educational benefits are substantially limited (Thang 2004).

In March 2004, Vietnam formally adopted the master plan called "Applying and Developing Open Source Software in Vietnam for the 2004-2008 period". The plan has three objectives (Asia OSS, 2004):

- Accelerating the application and development of open source software (OSS), enhancing copyrights protection and cutting costs of software purchase, promoting the development of Vietnam's information technology in general and software industry in particular.
- Forming a base of competent technical experts who master advanced technology and leverage their creativity in OSS application and development.
- Creating some typical IT products that respond particularly to domestic conditions and practical needs of OSS development.

As a part of this effort all PCs made and sold in Vietnam will be equipped with a Linux operating system and open source office applications. This applies also to IT hardware used in the educational sector. Reducing the degree of piracy software in Vietnam is yet another objective. The government has stated that popularizing open source software alternatives would reduce the average citizen's demand for illegal copies of commercial software. Another likely objective for the encouragement of open source software is to meet the requirements of a free trade deal signed with the United States in 2001. This is an agreement in principle on a bilateral market access that will lower trade barriers to a wider range of U.S. industrial and agricultural products. This deal is also intended to help clear the way for Vietnam's accession to the World Trade Organization (WTO), which terms has been negotiated since 1995 (US Trade Representative 2006).

The Vietnamese IT industry's future prospects seem brighter as it recorded sales of USD 685 million in 2004. This is a 33 percent surge compared to last year, and reflects the initiatives to widen IT use in the country. Surveys conducted by international firms shows Vietnam's IT sector growing at an average annual rate of 25 percent in the coming years. Sales have been dominated by hardware purchases, which have accounted for approximately 80 percent of total IT spending between 2000 and 2005. This focus on hardware reflects mainly the widespread piracy of software (US Commercial Services 2005). As of November 2005, Vietnam had 38 licensed internet service providers, 2.8 million internet subscribers with 10 million internet users, equating to 12 percent of the total population. The total international bandwidth was 3.5 Tbps (US Commercial Services 2005).

5.5 ICT in health system

The Ministry of Health maintains a national health management information system (HMIS), which has undergone significant changes over the last few years in order to suit the general development process of the country. A large amount of routine health data is collected from all levels of the health system hierarchy and is seen as important for assessing the health situation of the people (Heywood 2005). A set of 121 defined health indicators and methods for data collection is gradually approaching international criteria. Still, the national HMIS shows some fundamental inadequacies and limitations, particularly with regard to processing, analysis and feedback. The set of health indicators is to some degree incompatible with the enormous amount of data collected and implies a burden to the health workers (ibid.).

According to the Ministry of Health, computerisation is applied at the district level and above. My research revealed that this is a truth with modifications, as several visits to district offices without computers were made. Statistical workers at the district offices are responsible for entering data from the lower levels into the computerised information system. Aggregated data is exported to the provincial level and eventually to the national level. They are as of October 2006 not being effectively used in monitoring, managing or planning activities at the level of data collection. Problems related to parallel flows of information, vertical health programs with overlapping information, not standardised report formats and different milestones for collecting similar routine reports are affecting completeness and accuracy of data at provincial and national levels.

Compilation and analysis of data is still manual at all commune health stations and at higher levels with limited computerisation. Data generated by health software is usually in formats like Epi Info and MS Excel. A number of software applications have been tested in pilot district health centres and hospitals. A majority of these systems are intended for compilation of data and generation of formatted reports, and is not focusing on data analysis for management purposes.

6 DHIS 2

The following sections will provide a presentation of the development frameworks and communication and coordination tools being used in the project, as well as an overview of the design and key concepts of the system. Knowledge about these matters has been derived from my development participation within the project.

6.1 Development frameworks

In the following paragraph I will present the commonly used development frameworks in the DHIS 2 project. All of the mentioned frameworks are open-source and Java based.

6.1.1 Maven

Maven is a software project management and comprehension tool. Based on the concept of a project object model (POM), Maven can manage a project's build, reporting and documentation from a central piece of information and thus provide a uniform build system. Maven takes care of the dependency management by automatically downloading dependencies from a remote repository and installing them in a local repository, available to all projects. Maven can provide mailing lists and unit test reports, and offers guidelines to best practises to project directory layout and unit testing. DHIS 2 takes advantages of all of the mentioned features (Maven 2006).

6.1.2 Hibernate

Hibernate is an object-relational mapping system that let you store plain Java objects to a database. It is open source based and distributed under the GNU LGPL License. Hibernate works only with relational databases, and only over JDBC. Hibernate's persistence strategy is known as transparent persistence because the model that are build contains no persistence code of any kind. Using Hibernate or similar systems have several advantages. The developer is able to work with objects instead of relational databases, and won't have to change the source code if another database is preferred. Hibernate generates SQL calls and provides automatic result set handling and object conversion. Hibernate was developed by a team of Java software developers around the world led by Gavin King (Hibernate 2006). DHIS 2 is currently being used with Resin, MySql and PostgreSQL as database management systems.

6.1.3 Spring

Spring is an open source lightweight application framework intended to make J2EE development easier. It consists of a container, abstraction layers for transaction management and JDBC, integration with ORM systems; aspect oriented programming functionality and a MVC web application framework. The layered architecture provides flexibility and the opportunity to freely pick the services needed. One main capacity of Spring is to wire application objects according to the principles of *Inversion of control* and *Dependency*

injection. Spring lets the developer manage Java beans and dependencies in a complex system through a set of configuration files. All objects in DHIS 2 which provides services are mapped as beans, which keep the system easy to change and extend. Another main task of Spring is to promote good programming practise by enabling a POJO-based programming model (Spring 2006). DHIS 2 adheres to these guidelines by its extensive use of Java objects.

6.1.4 WebWork

WebWork is a Java web-application development framework. It is built specifically with developer productivity and code simplicity in mind, providing robust support for building reusable UI templates, such as form controls, UI themes, internationalization, dynamic form parameter mapping to JavaBeans, robust client and server side validation (WebWork 2006).

WebWork is used in combination with Velocity, which is a Java-based template engine. It permits the developer to use a simple and powerful template language to reference objects and variables defined in the Java code. Velocity provides separation of web design and code logic, making it more maintainable and fit for division of labour (Velocity 2006).

WebWork is built upon XWork, which is a command-pattern framework that is used to power WebWork as well as other applications. XWork provides an Inversion of Control container, a powerful expression language, data type conversion, validation, and pluggable configuration (XWork 2006). Every DHIS 2 web project uses XWork and WebWork for the presentation layer.

6.1.5 JasperReports

JasperReports is a powerful open source Java reporting tool that has the ability to deliver rich content onto the screen, to the printer or into various formats like PDF, HTML and XLS. It is written in Java and can be used in a variety of Java enabled applications including J2EE or Web applications to generate dynamic content. Its main purpose is to help creating page oriented, ready to print documents in a simple and flexible manner. JasperReports provides the necessary features to generate dynamic reports, including data retrieval using JDBC (Java Database Connectivity), as well as support for parameters, expressions, variables, and groups. JasperReports also includes advanced features, such as custom data sources, scriptlets, and sub-reports. In the past, report generation has largely been the domain of large commercial products such as Crystal Reports. JasperReports is considered as the leading open source report engine and provides Java developers with a viable alternative to commercial software. JasperReports plays a central role in the DHIS 2 report tool module.

6.1.6 JFreeChart

JFreeChart is an open source free chart library that makes it easy for developers to display professional quality charts in their applications. JFreeChart's feature set includes a flexible design that is easy to extend and targets both server-side and client-side applications. JFreeChart allows you to easily incorporate advanced charting capabilities into Java applications, and has support for many output types including Java swing components, image files and PDF files. JFreeChart can be embedded and used to display graphs in JasperReports

reports. The library is able to generate the most common chart types including pie, bar, line, and Gantt charts. JFreeChart is embedded in JasperReports and used in the DHIS 2 report module.

6.1.7 iReport

iReport is a powerful and easy-to-use visual report builder and designer based on the JasperReports report framework. iReport is a desktop application which is written in Java. It allows users to visually edit complex reports with charts, images and sub-reports. iReport is integrated with leading open source chart libraries for java such as JFreeChart. Report data can be retrieved in several ways including JDBC connections, Java beans, Hibernate and XML files. iReport is used to edit reports in connection with the DHIS 2 report module.

6.1.8 BIRT

BIRT is an Eclipse-based open source reporting system for web applications, especially those based on Java and J2EE. BIRT has two main components: a report designer based on Eclipse, and a runtime component that you can add to your app server. BIRT also offers a charting engine that lets you add charts to your own application. With BIRT one can add a rich variety of reports to the application including lists, charts, cross-tabs and documents. BIRT makes it possible to add totals, averages and other summaries of numeric data used in the report.

6.1.9 xStream

XStream is a simple library to serialize objects to XML and back again. It provides a high level facade that simplifies common use cases. It allows for serializing most objects without need for specifying mappings. Speed and low memory footprint are a crucial part of the design, making it suitable for large object graphs or systems with high message throughput. No information is duplicated that can be obtained via reflection. This results in XML that is easier to read for humans and more compact than native Java serialization.

6.2 *Communication and coordination tools*

In the following section I will present the tools used for communication and coordination in the DHIS 2 project.

6.2.1 Subversion

Subversion is an open-source version control system. Subversion manages files and directories over time. A tree of files is placed into a central repository. The repository is much like an ordinary file server, except that it remembers every change ever made to your files and directories. This allows the developer to recover older versions of data, or examine the history of how data changed. Subversion can access its repository across networks, which allows it to be used by people on different computers. At some level, the ability for various people to

modify and manage the same set of data from their respective locations fosters collaboration. Progress can occur more quickly without a single conduit through which all modifications must occur. Versioning of data also gives the developer the opportunity to undo incorrect changes (Subversion 2006). Development in the DHIS 2 project are scattered around the world, and Subversion makes it possible for everyone to work simultaneously on the same code base. The HISP strategy for code integration and collaboration implies that developers from all development nodes make frequent commits to the central code repository in order to facilitate coordination and code integration.

6.2.2 JIRA

JIRA is a bug tracking, issue tracking, and project management application developed to make these processes easier for development teams. Jira features customisable dashboards, real-time statistics, full text searching, powerful filtering and easy integration to other systems such as e-mail, RSS and source control. Jira is commercial software, but a price discount is given to academic institutions (Jira 2006). The DHIS 2 project uses JIRA and every project has its own section. The developers use it to keep bug and issue tracking consistent and informative, which eases the challenge of coordination and communication in a scattered developer community. The project coordinators use it as a control and management tool where they are able to track the progress and status for every project.

6.2.3 Confluence

Confluence is an enterprise wiki and is the backbone for communication in the DHIS 2 project. Wiki is a group communication mechanism that allows users to freely create and edit web page content using a web browser. Wiki supports hyperlinks and has simple text syntax for creating new pages and cross-links between internal pages. The DHIS 2 part of the wiki contains developer guides and tutorials for the various technologies and tools, a specification document, information about the system design, a project roadmap, information about the active developers and relevant research projects.

6.2.4 Mailing lists

The DHIS 2 project uses three different mailing lists. The developer list is used for issues related to the technical development of the system. The scm list includes e-mails automatically generated by Subversion when a developer commits an update to the central repository. The user list contains issues, questions and bug reports regarding the usage of DHIS 2. The mailing lists are stored in web archives. This is favourable when needs for going back and referring to previous discussions and decisions emerge.

6.2.5 Instant messaging clients

Instant messaging clients like Microsoft Messenger and GAME are the most widespread means for synchronous communication in DHIS 2. Instant Messaging is a form of electronic communication which involves immediate correspondence between two or more users who are all online simultaneously.

6.3 Key concepts

In the following section I make a brief explanation of the key concepts, objects and terms of the DHIS 2 system, and provide a diagram which displays the relations between the various objects (ref. Figure 2).

Data element

The data element denotes a set of parameters related to a medical phenomenon like a diagnosis, treatment, procedure or physical actions performed by a patient, doctor or nurse. An example of a data element is *Typhoid Fever - male under 1 year*. Data elements can be grouped in data element groups.

Organisation unit

An organisation unit is the definition of any medical institution or statistical office at any level in the health hierarchy. An organisation unit can be a hospital, ward, district office, provincial office or the national ministry of health. The organisation units are organised in a tree hierarchy, implying that units may have a parent and a set of children. Organisation units can be grouped in organisation units groups.

Data set

The data set is a collection of data elements for which an organisation unit is supposed to collect and register data. The data set defines the time interval which the data is supposed to be registered for and the type of data supposed to be registered. A data set is tied to an organisation unit and may inherit from a parent data set. An example of a data set name is *Notifiable Diseases Weekly*.

Indicator

An indicator contains a formula which is intended to describe the state of a medical phenomenon. The state can be described as a rate or a ratio. An example of an indicator describing a rate is:

Infant tested for HIV = Infant tested for HIV / Live birth to woman with HIV

Data value

The data value represents a registered value in the database, and is identified by the data element and the period it was registered for and the organisation unit which registered the value. The registered value can be a number, a text sequence or a true-false value.

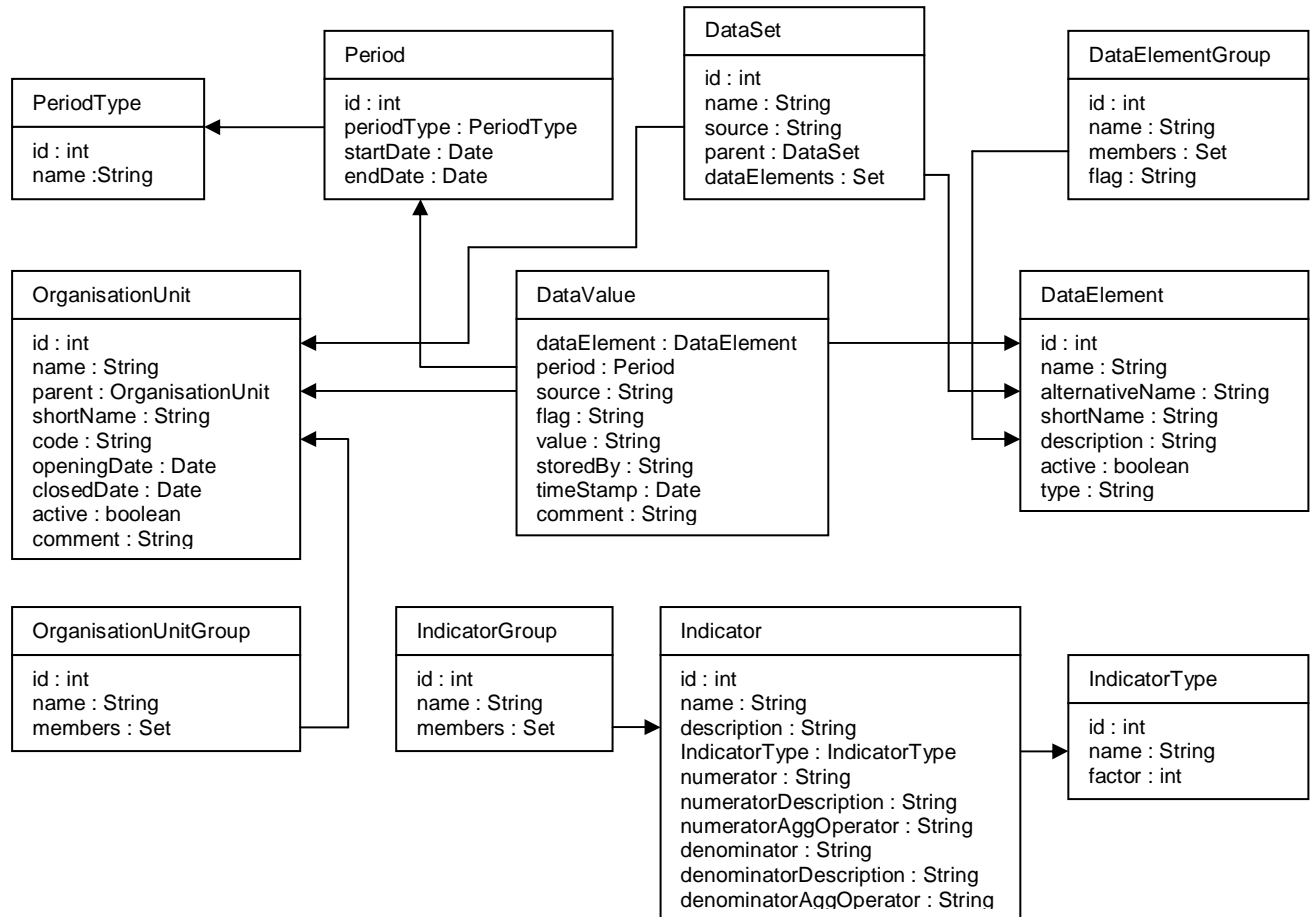


Figure 2: Class diagram showing the relationship between the core value objects

6.4 System design

The following section will give a brief explanation of the design of the DHIS 2 system (ref. Figure 3). The DHIS 2 core modules are responsible for data persistence. Basic operations like retrieving, updating, adding and deleting data are performed by the store modules. The service modules contain the business logic, like functionality for aggregation of data, data mart, import and export, validation, user administration, user options, and internationalisation. Aggregation of data denotes aggregation over several periods of time and several organisation units in the hierarchy. Data mart is a kind of a data warehouse, where data is aggregated and exported to dedicated tables in the database. The advantage of keeping a datamart is related to integration of external information processors and reformatting of data (see 8.2 for further elaboration). The DHIS 2 core also provides modules that support the use of application frameworks like Hibernate and Spring, testing, and transaction management.

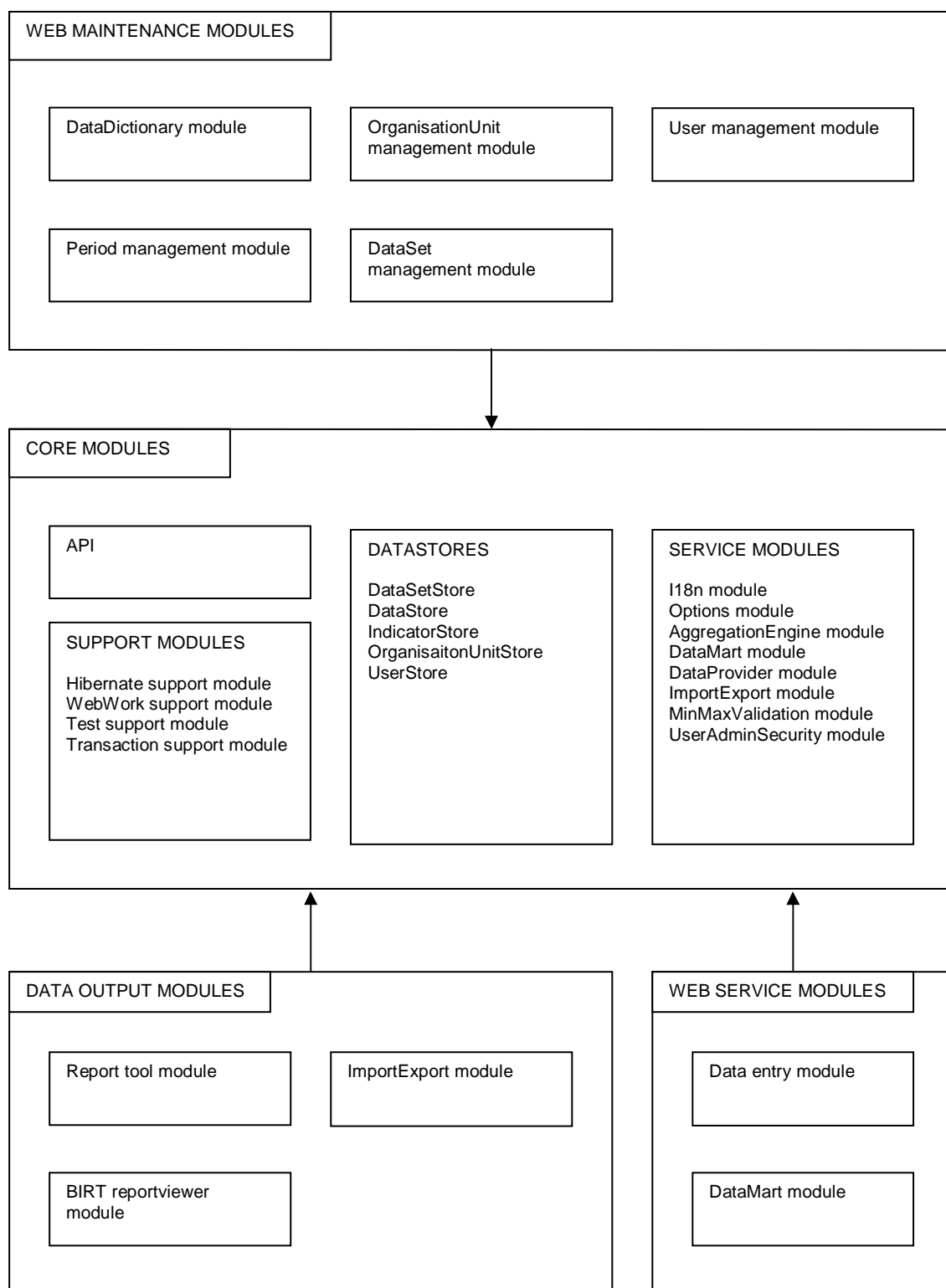


Figure 3: Overview of the modules in the DHIS 2 system

DHIS 2 contains several web modules built upon the core. The web modules can roughly be divided in three. Firstly, the maintenance section provides administration of metadata definitions. Metadata in this connection refers to data elements, indicators, organisation units, users, periods, and data sets. These modules provide functionality for adding, deleting, updating and retrieving such data, as well as management of the respective groups.

Secondly, the data output section contains two reporting modules and an import-export module. The first report module is a general module optimized for creating detailed reports, and will act as basis for the discussion in chapter 8. The second report module is based on the BIRT reporting framework (ref. 6.1.8), which is favourable for dynamic and flexible reports. The import-export module uses an XML formatted file for interchange of data between DHIS 2 installations, and provides interfaces for complete and detailed exports.

Thirdly, the service section contains modules for data entry and datamart functionality. The data entry module lets the user enters data for a given organisation unit, data set and period. The datamart module provides the user with a basic and a detailed interface for exporting data to the datamart.

As demonstrated in Figure 3, the DHIS 2 design is highly modularised, and the presentation layer is composed of fairly independent modules. The design is intended to reflect the structure of the DHIS 2 project, which consists of development nodes in Oslo, Vietnam and India. Hence, modularisation is applied to the design in order to allow for distributed development.

7 The HISP Vietnam project

In the following chapter I will account for the actions and efforts for developing, implementing and sustaining various versions of the DHIS systems carried out by HISP in Vietnam.

7.1 *First HISP implementation effort in Vietnam*

HISP's first implementation effort in Vietnam started in July 2004 and ended during the fall of 2005. The following section presents the actions, agreements, and implementation processes carried out during this period.

7.1.1 Initial contact between HISP and Vietnamese authorities

The HISP effort in Vietnam started as an indirect consequence of the Vietnamese government's commitment to applying and developing open source software (ref. 5.4). The government had become aware of HISP through its growing reputation earned in South Africa. In July 2004, the government contacted the HISP project leader and invited him to an open source conference in HCMC called COSGov. This conference aims at bringing together public and private sector professionals in an attempt to transform government operations through open source software. HISP was allowed to introduce its organisation and the DHIS software among several other case studies. This effort resulted in a request from the Vietnamese government to initiate a formal collaboration regarding development and implementation of health information systems in the Vietnamese health sector.

The project leader also established contact with a software outsourcing company in HCMC and a company in Hue that were interested in contributing to the HISP efforts in Vietnam. The chief executive at the company from HCMC (referred to from now as *OutSoft*) was excited about the HISP organisation and was eager to contribute to the process. Later an agreement that would secure HISP the work power of three interns from his company was concluded. The company from Hue volunteered to support the DHIS implementation in Hue with regards to training and technical support.

7.1.2 First agreement on implementation

In a subsequent stay in Vietnam in October 2004 the project leader concluded an agreement with the Vietnamese Ministry of Health that permitted HISP to implement the DHIS software in the health provinces of HCMC, Hanoi and Hue. In January 2005 the project leader went back to Vietnam to meet with the Ministry of Health (MoH) in order to negotiate the terms of the agreement and initiate the implementation process.

HISP's strategy was to establish individual project agreements with the mentioned provinces. The agreements with the health departments in HCMC, Hanoi and Hue were endorsed by the Ministry of Health. Still there was an urgent need to develop a project framework where the MoH had a clearly defined role with specific responsibilities (Braa 2005).

HISP realized that an eventual implementation scale up to a nationwide level was heavily dependent on strong support from the Ministry of Health. However, in order to get started and show that the HISP implementation approach and the DHIS software was appropriate, it was considered as vital to carry out pilot implementations. Selecting both urban and rural provinces were regarded as favourable in order to get a comprehensive test of the approach and software since they represent huge differences in terms of infrastructure.

The data standards, paper based tools and computer based tools for data collection and reporting were all developed by the Statistical Department of the MoH. Collaboration with this department was considered as crucial in order to achieve the goals of strengthening and further developing the national health information systems.

The agreements with the health departments in HCMC and Hue had in common that they stated that DHIS would be implemented first in some pilot districts before the process was scaled up to cover the whole cities. The reporting strategy implied that the wards and health units would submit their paper based reports to the district office. The data would be entered electronically into DHIS at the district office before it was exported and sent to the province office electronically by e-mail. Four main challenges were identified regarding the implementation processes (Appendix D and E):

Firstly, the health departments suffered from a shortage in support personnel and HISP did not possess a dedicated technical person to support the implementation process. To improve this situation it was suggested that HISP could employ a person to work with the health departments with both implementation and development.

Secondly, the organisational complexity of health programs and districts in HCMC, the lack of central project leadership in MoH, and the city's great extent implied problems related to coordination and management. Because the HCMC health department had not set up a central leadership of the project, it suffered from an absence of leadership above district level in the management structure. To improve this situation the director of one of the pilot health programs agreed to take charge and become the project manager. This situation was favourable since the director had the authority to direct the units at district level and spoke English fluently.

Thirdly, some districts suffered from a general challenge regarding reporting routines. The district database was located at the statistical office. The problem was that the various health program specific paper reports were sent directly from the wards to their respective health programs at district level, and not to the statistical office. According to the official regulations the wards were intended to report to the statistical office, which would enter the data in the district database and then distribute it to the various health programs as well as the health province. Due to strong health program linear management and out of old habits and convenience each individual health program organized their own reporting and statistic program in defiance of these regulations. To improve the situation the director of one pilot health program agreed to supervise and ensure that the new routines were complied with. This was essential in order to achieve HISP's goal of structuring this fragmented reporting chain by creating a unified and integrated district database.

Fourthly, the purchase of computers to the second pilot district was delayed and rendered electronic data capture impossible. The district database system also suffered from a lack of local authority to enforce a new reporting structure.

The agreement stated that training and capacity building was a critical component of the implementation and had to be carried out at three levels:

- The health department had to be able to run, maintain and troubleshoot the system on a daily basis. This capacity would be ensured through strong participation from the health department in all stages of the DHIS adaptation and implementation.
- Each unit at district level had to allocate at least two staff members to undergo training in basic system functionality and maintenance as well as information management. Training courses would be organized by the health department and HISP would conduct the training.
- In addition to the basic technical capacity to run the system, training would also need to address analysis and use of information for management and health services delivery. This had to be done in collaboration with a health educational institution.

7.1.3 First implementation process

The DHIS 1.3 implementation process started in November 2004. The system was initially implemented in two pilot districts in HCMC and scaled up to cover most of the health districts in HCMC within the first months of 2005. Several issues that negatively influenced the process emerged:

Firstly, the main problem turned out to be the absence of a working report generator. The current report module was developed by the HISP employee at OutSoft, but had some serious flaws which he had not corrected. Several reminders and requests did not lead the employee to fix the problems. This left the districts without the ability to produce output from the system, and was embarrassing for the HISP Vietnam organisation as they apparently lacked the ability to improve the situation. These problems led to annoyance among the users and some of the districts to refuse using the system in their daily work.

Secondly, the DHIS installations also experienced problems like computer failures, virus attacks and Vietnamese font problems. DHIS 1.3 is programmed in Microsoft Visual Basic 6 which does not fully support the Unicode format. Unicode is an industry standard designed to allow text and symbols from all of the writing systems of the world to be consistently represented and manipulated by computers, and thus used to represent the Vietnamese language in the system. The defiance entailed severe problems regarding translation of the user interface.

Thirdly, the implementation process suffered from a lack of support personnel able to perform training and initialize learning processes. HISP had concluded an agreement with a large outsourcing company in HCMC among other reasons to obtain proper implementation support resources. The agreement stated that a Norwegian master student would be responsible for training some of the interns at the company as a part of the internal training and development program. The interns would work with DHIS 2 related development, and act as support personnel for the ongoing implementation process. However, after some time, the interns announced that they were not willing to participate in the implementation process. Firstly, they wanted to focus merely on software development. Secondly, they were only interested in

Java and open source technologies, which conflicted with the system being implemented at the time; the MS Access based DHIS 1.3. Thirdly, they stated that they felt no ownership and joint responsibility for the DHIS 1.3 system, as it had been developed mainly by the HISP development team in South Africa. A similar conflict of interests emerged in relation to HISP's partner university in HCMC. The head of faculty was reluctant regarding repairing the report generator module as it implied working with Microsoft proprietary technology, which conflicted with the "open source profile" maintained by the university (ref. 7.7.4). Also, the lack of suitable resources for training and follow-up led to the usage of the system being constrained by health workers without basic computer skills or necessary knowledge about the system.

At most, 17 districts were submitting data electronically upwards in the organisation unit hierarchy. Still, the working routines demanded the health workers to send paper reports in parallel, meaning that no efficiency improvements were gained. The last HISP training session was conducted in July 2005. Even if the DHIS 1.3 implementation had entailed fewer problems compared to the previously used HMIS system, the usage of the system faded away during the autumn of 2005.

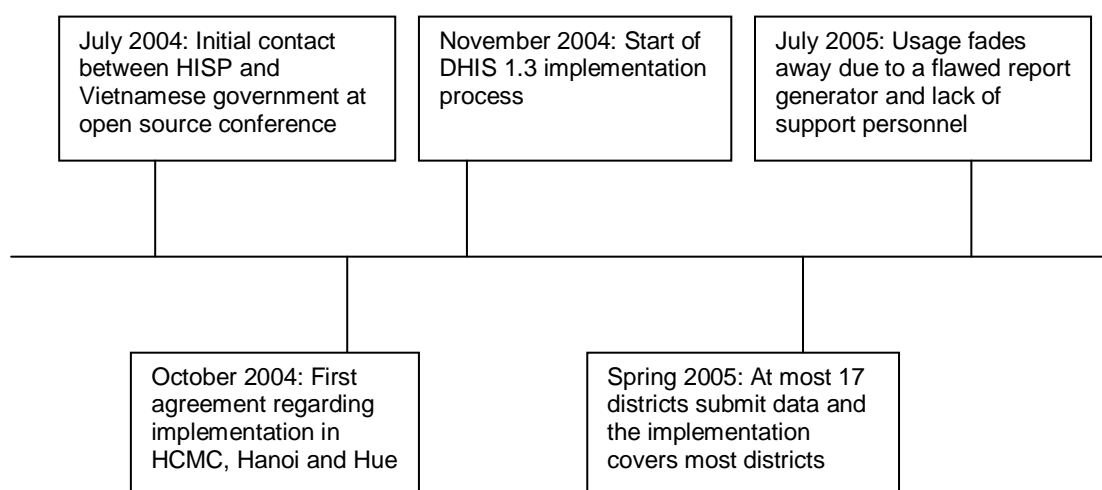


Figure 4: Timeline with major events during the first implementation effort

7.2 Second HISP implementation effort in Vietnam

A second implementation effort in Vietnam in November 2005 followed in the wake of the previous DHIS 1.3 implementation failure. The DHIS version scheduled to be implemented was the 1.4 version.

7.2.1 Collaboration with the Ministry of Health

During the first week of my field work in Vietnam the HISP project leader and the HISP coordinator in Vietnam went to Hanoi to meet with the Planning and Financial Department of

the Vietnamese Ministry of Health (MoH). Their intention was to make an agreement with the MoH regarding collaboration on the development of an open source health information system and the terms for the implementation of the DHIS 1.4.

The resulting memorandum of understanding (MoU) stated that the first aim of the collaboration was to develop a completely open source software application for the collection, processing, analysis, communication and dissemination of health information in Vietnam (ref. appendix C). This goal has to be seen in relation to the Vietnamese government's strategy to move public sector software to an open source platform (ref. 5.4). The second aim of the agreement was to strengthen the human resource capacity in the area of development and health information systems in the MoH and in Vietnam more generally.

7.2.2 Plan for development

MoH had previously developed a MS Access based system named Health Management Information System (HMIS). This system was customised to cover the requirements of the MoH. It contained hard-coded forms for entering data and hard-coded reports similar to the paper based reports in use. The system was easy to use for the health workers since the electronic forms looked almost exactly like the paper forms they were used to. The system contained on the other hand no functionality for evaluating and analysing data.

The MoU stated that HISP in Vietnam had customized the DHIS 1.4 to the conditions in Vietnam and implemented the software in Hue and in Ho Chi Minh City. The plan for the implementation had two steps:

Step 1 implied merging the HMIS and the DHIS to a combined and integrated software application suit (ref. appendix C). In other words, the HMIS would be used for data input and DHIS 1.4 as a tool for evaluation and analysis of data. Various Java modules planned for DHIS 2 would later be integrated in this system to provide additional functionality. Modules being planned at the time included a report generator module, an import-export module and a geographical information system (GIS) module. This hybrid-application would be replaced by DHIS 2 when it was ready to be released.

Step 2 entailed replacing the previously mentioned application completely with the open source based DHIS 2. DHIS 2 would by then be an adequate replacement for DHIS 1.4 and contain functionality for data input and reporting as well as analysis. The system would be completely web-based and capable of running both remotely and locally; the latter alternative intended for users without or reduced internet connectivity.

7.2.3 Development challenges

The system described in the first step of the implementation process in the MoU was intended to use HMIS for data input and DHIS 1.4 for data persistence and analysis. DHIS 1.4 provided no report functionality, so the reporting requirements were delegated to a preliminary non-existing Java report generator module. This left me and the other DHIS 2 developers with the following three challenges:

- A bridge between the HMIS data entry forms and the DHIS database had to be developed.
- The bridge functionality in DHIS 2 that made the system able to communicate with the DHIS 1.4 database was incomplete, and had to be finished in order to integrate e.g. a Java-based report module in the system.
- A Java and web-based report generator had to be developed. This application should preferably be able to work with data from both DHIS 1.4 and DHIS 2.

7.2.4 Plan for implementation

The implementation plan stated that the system would be implemented in pilot provinces in HCMC, Hanoi and Hue. The system would be developed and implemented in a close collaboration between the MoH and HISP Vietnam, and HISP would support the MoH in developing human resource capacity. In order to achieve this goal HISP would employ one person to work with the MoH in Hanoi. This person was intended to work on the HMIS and DHIS merged software application and support the implementation of this software first in Hanoi and thereafter in other provinces. This person would be trained by HISP and work closely with the development teams in HCMC and Hue.

The initial implementation plan for HCMC aimed at selecting two hospitals with previous experience in using DHIS 1.3. One advantage with this was that the amount of training needed would decrease if the health workers were used to entering data electronically. It was also regarded as favourable to start with a few locations before moving on to the whole city. It would be easier to correct possible errors on a few installations and then implement the improved system than having to correct several installations.

Making a good first impression on the various districts was considered important. The previous DHIS 1.3 system had been flawed, many users had been disappointed with it and it would be crucial to regain their confidentiality. The main tasks regarding accommodating DHIS 1.4 to the Vietnamese setting was:

- Set up organisation unit groups, data element groups and data sets.
- Translate and adjust the user interface to Vietnamese.
- Install the report generator of the HISP employee in Hue.
- Create sample pivot tables for Microsoft Excel based on the data mart database.
- Find a suitable strategy for making data captured in DHIS 1.3 compatible with the 1.4 version.

The mentioned report generator was a kind of ad-hoc solution based on JasperReports (ref. 6.1.5) developed by the HISP employee in Hue. The reports had to be designed in iReport (ref. 6.1.7) and populated with the desktop report generator application. The disadvantage with this solution was that the HISP employee was the only person capable of designing such reports; additionally it was a quite time-consuming task. On the other hand, it was the only alternative for generating reports at the time.

A full release of DHIS 2 was scheduled in December 2006. In November 2005 the HISP project leaders decided to schedule a release of a light version in January 2006. The main reason for this decision was to support the requirements from a HISP pilot district in India.

Another reason was to encourage the development of outstanding web modules by maintaining a deadline. Completing these modules was necessary in order to get feedback and suggestions for improvements from users.

7.2.5 Meeting with the IT manager of Planning and Financial Department

During the first week of my field work in HCMC I met with the IT manager from the statistics office in Planning and Financial Department of the MoH. He stayed in HCMC for a few days and was interested in getting to know the DHIS 1.4 system. I gave him a presentation of approximately 45 minutes. The presentation passed without major problems, although I experienced a few bugs. The IT manager was impressed by the flexibility and wide range of opportunities provided by the system. Still he was disappointed by the lack of proper report functionality. He emphasised vigorously the need of seeing the system in real action, meaning he would like to see how the system was intended to be used in real life. He was not that interested in seeing the maintenance part; he would like to see what the system had to offer for Vietnamese health workers. The IT manager suggested that for our next meeting, I would have prepared some presentation slides and a database with realistic data for HCMC. He indicated that he would like to visit a health facility actually using the system.

The IT manager was concerned about the complexity of DHIS 1.4. He approved the conflict between flexibility and simplicity, but was doubtful regarding the user friendliness of the system and availability for Vietnamese health workers. He also expressed concerns regarding the bugs which emerged during my presentation in relation to the fact that the system has been in development for several years.

7.2.6 Support resources

The implementation processes of DHIS 1.3 and 1.4 both experienced a deficit in support resources with a view to personnel and teaching materials. The partner university's self-declared status as an "open source university" (ref. 9.7.4) made it difficult to get some of the students from the student group to support the implementation of the proprietary Microsoft Access based DHIS 1.4. The only official support person in HCMC was the HISP employee from OutSoft. During my field work in Vietnam he stayed in Oslo, where he studied for this master in information systems, and returned to Vietnam in February 2006. The only other official support person in Vietnam at the time was the person HISP had employed in Hue.

7.3 Customising DHIS 1.4

The MoH had pointed out one health program in HCMC to act as a pilot centre for the DHIS implementation. In the early beginning of the process of customising DHIS 1.4 I went to meet an IT worker at the office of the partner health centre in HCMC. The IT worker was a very busy man and it often turned out to be difficult to get appointments. At my first meeting he was not even aware of me coming, in spite of assurances from the HISP coordinator in Vietnam. The intention of the first meetings was to set up basic meta data like data sets, data element groups, and organisation unit groups, as well as convince the IT worker of the potential benefits this entailed during data analysis. According to the HISP coordinator in

Oslo, we were supposed to collaborate on gathering and filtering this information, but the IT worker told me that he was able to perform this task on his own.

The process of translating the user interface of DHIS 1.4 to Vietnamese turned out to be complicated due to Microsoft's limited support for Vietnamese characters. The only person with adequate language skills as well as technical skills regarding DHIS 1.4 was the HISP employee in Hue. DHIS 1.4 can be extended to other languages than English through its internationalisation functionality. This functionality requires the user to translate a language file to the desired language and then switch locale in the global settings in Microsoft Windows. Unfortunately, the Vietnamese locale only exists in Windows XP and not in their predecessors Windows 2000 and Windows 98. As most of the DHIS users in Vietnam still were running the last-mentioned operating systems, this solution was unacceptable.

The IT worker at the partner health centre considered DHIS 1.4 as a powerful and flexible system. His opinion was nevertheless that some of the functionality was unreliable and erroneous, and that just over half of the user interfaces were translated to Vietnamese. The Microsoft Excel pivot table functionality intended to be used in connection with the DHIS 1.4 datamart tables was perceived as confusing, and had not been used because none of the users had been able to comprehend how to make and employ them.

The HISP employee in Hue came to HCMC at the end of December to work with the IT worker and me for one week. She had translated most of the DHIS 1.4 user interface and set up a Vietnamese data file. The IT worker had almost completed the grouping of organisation units and data elements. The HISP employee answered the IT workers questions regarding grouping, and he later completed the setup. The IT worker had experienced problems with the Vietnamese fonts not rendering properly. This problem was due to the Vietnamese fonts not being installed in the operative system, and was quickly fixed. The HISP employee made some simple adjustments of the design of the user interface by using the UI designer in Microsoft Access. She installed her report generator application which turned out to work as intended. After three days of work the system was accommodated to be used in HCMC health province. The most essential functionality like data entry and exporting to data mart was working without significant problems.

7.3.1 Data conversion from DHIS 1.3 to 1.4

Some of the districts in HCMC had been collecting considerable amounts of data using the DHIS 1.3 version. Thus the IT worker needed to be able to make the data files from the 1.3 version compatible with the 1.4 version. The HISP coordinator in Oslo proposed a strategy where a master database was made. Data from all of the locations would be exported to a text file and imported to the master database accordingly. Later, the master database would be deployed to the various locations. The advantage of this strategy was that the database would stay conform and that meta-data like data elements and groups only would have to be entered once. The HISP employee replied that she never had experienced any problems regarding database conformity, that she already had produced support material for the end-users and that she would like to create the database at every location. She claimed that by following the first-mentioned strategy the user would be able to see the units from the whole organisation tree, which had the potential of being confusing. Even if the project coordinator objected that there was a function for setting an organisation unit as default, the HISP employee decided to go with the last-mentioned strategy.

The intention of making sample Excel pivot tables was to give the end-users a template which they could base their own pivot tables upon. The project coordinator guided the HISP employee step-by-step through the procedure during an instant messaging conversation, using a file developed in Botswana as basis.

7.3.2 Organisation structure

The current organisation unit structure contained the levels country – province – hospital group – hospital. The hospital group level functioned as a work-around solution in DHIS 1.3, used in order to be able to filter the hospital units. This requirement would be solved by the grouping functionality introduced in the 1.4 version. Thus we decided to change the organisation structure to contain the levels country – province – district and hospital – ward. Wards could only belong to a district, and both hospitals and districts belonged to a province. This required us to change the parent of the hospitals from hospital group to province; thus we had to change the parent of the six hospitals residing under the HCMC province. Another important change that emerged during the change from DHIS 1.3 to 1.4 was that data entry was allowed at any level in 1.4, in contrast to 1.3 where data entry only was allowed at level five.

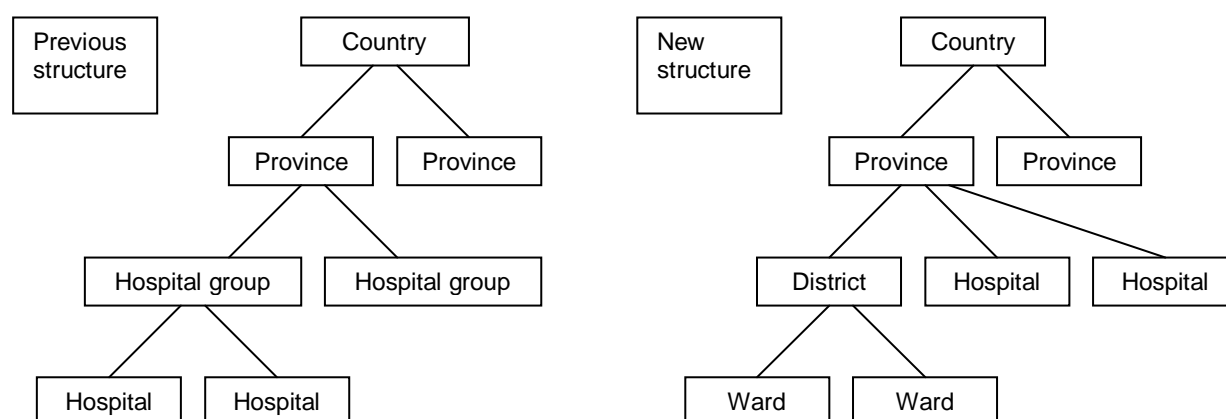


Figure 5: Changes in the organisation structure

7.3.3 End of DHIS 1.4 implementation process

At the end of December 2005, the plan of implementing DHIS 1.4 in HCMC was abandoned. There were several reasons for this decision. Firstly, HISP's partner university in HCMC (ref. 7.1.3) maintained a reluctant attitude against proprietary technologies, which entailed that they were not interested in supporting the Microsoft Access based DHIS 1.4 system. Secondly, the development of the DHIS 2 light version progressed quickly. Spending development resources on improving and adapting the DHIS 1.4 version, which according to the long term plan was intended to be replaced by the DHIS 2 system, was seen as unreasonable.

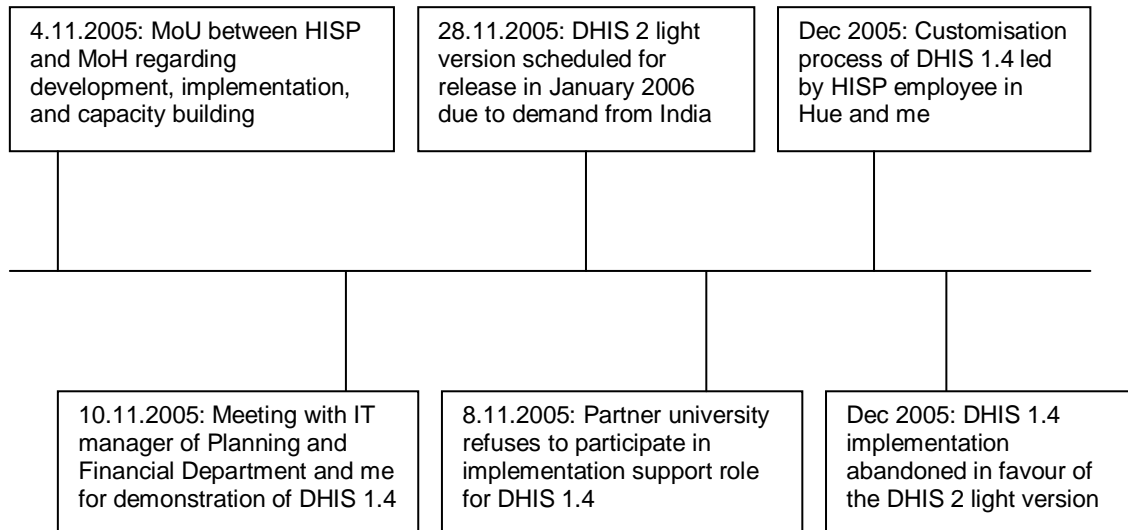


Figure 6: Timeline with major events during the second implementation effort

7.4 Third HISP implementation effort in Vietnam

The third HISP implementation effort in Vietnam started in July 2006. The DHIS version intended to be implemented was the open source based DHIS 2. In the following paragraph I will account for the conditions, status at the time of writing and plans for the implementation process.

7.4.1 Conditions for HIS implementation

In the following section I will account for the conditions for implementing the DHIS 2 in Vietnam. The information is partly based on derived knowledge from my field work and participation in the implementation process. The Vietnamese health information systems and structures emerged to have the following characteristics:

Reasonably well defined and structured reporting systems

The MoH is the top government organization of every health program. The MoH has a set of departments that manages its functions and programs which again are supported by its career organization units directly under MoH. Commune health centres are required to send 9 primary registers, 1 card and 3 set of reporting forms while districts send 15 reports and the provinces sends 16 reports.

The actual transmission in this information flow is however not always sent by mail in the specified periods. They are often handed over at the occasion of meetings, especially the reports from the districts. Many are not filed at all, and there are no guidelines on how to handle missing reports when calculating indicators (WHO 2005). The quality of the data collected at district level is also in many cases poor and unsynchronized with the top level indicators, causing the Vietnamese health system to lag behind the international standards (Heywood 2005).

Poor skills among staff

The Socio-Economic Development Plan (2006-2010) identifies improving medical staff in remote areas and improving staff performance as priorities. Human resources in the health sector can be divided into two major types: the professional staff and management staff in the first group, quite dominant in number, mainly involved in delivering health services; and the other group, much smaller in number, that is mainly involved in management tasks at both macro (MoH) and micro level (hospitals and wards). While the technical staff of the health sector is comparatively good in their professional competence, those involved in the management tasks would need substantial improvements in their capacity to do a good job. This weakness can be explained by the fact that Vietnam is in transition from command economy to market economy and thus expertise in market oriented management is generally lacking. It can also be explained by the fact that most of the management personnel in the health sector have a medical background and only few have an additional degree or professional training in management science or economics (Bijlmakers et al. 2006).

The only courses every civil servant in the health sector has to attend are the ones in public administration and in political training that is given to every other civil servant in the same form with the same content, regardless of their specialization and background. These courses are commonly assessed as superficial, formal and are rather needed for promotion purpose than for the knowledge or skills it provides. Management training and skills are also often provided within the framework of donor projects, but they are usually subject-specific rather than on general management and only accessible to those who participate in the project, who will not necessarily use or need the acquired skills later in their work (Bijlmakers et al. 2006).

Observations made by the HISP support personnel in HCMC and Hue indicate that the general level of computer skills among health workers are relatively poor.

“The users of DHIS still don't know much about computer, so we have to do training carefully. We just conducted training at two hospitals and two districts, but most of them ask us again about how to use the system.”

DHIS support worker in HCMC

Varying technical infrastructure

HISP support personnel in HCMC and Hue have made observations that indicate that the technical infrastructure in the biggest cities is varying. Some wards have stable and fast internet connections and possess modern computers which easily are able to run DHIS software. On the other hand, a large share of the wards does not possess computers at all.

“Most of ward level don't have computer, so we just implement in district and hospital.”

DHIS support worker in HCMC

Fragmented health structure

One of the biggest implications with the Vietnamese health system is related to the over 20 existing health programmes. PHC data is registered in connection with data for all health programmes at the ward level. The implication lays in the health programme data not being

reported directly to the statistical office; instead it is reported to the respective health programme offices at district level. Instead of having several independent reporting systems, the obvious solution would be sending all data directly to the central statistic office and then distribute it to the health programmes (Braa 2005). Another implication by this scheme is that it makes the work of registering more tedious and complicated as the same data must be written in several reports. The different programmes manage their own disease surveillance system. These systems are not satisfactory integrated in the routine information systems (Heywood 2005).

Huge amount of data collected

The doctors and health workers at the ward and health station level are expected to collect a huge amount of data as 30 routine forms and nine patient register books are filled out every month. The system suffers from overlapping in data reporting, as many forms intended for various recipients contain the same information. In addition, little feedback is given to the health workers regarding their data collection, which in all entails reduced motivation and poor data quality.

Parallel flows of information

As previously stated, the reporting routines suffer from parallel flows of identical information. Data from the ward level is sent to the district health centre, the provincial health office and to the Department of Planning and Finance at the Ministry of Health. The low degree of coordination reduces the ability to provide a comprehensive view of the data suitable for analysis and as a substantial basis for decision making.

Limited use of indicators

The national health management IS has defined a list of 121 indicators that cover all main health subsystems (Heywood 2005). Even if the intention of these indicators is promising, the data collected is not directly linked to use and basis for decision making.

7.4.2 Human resources

In the following section I will account for the human resources whom are available to carry out and support the HISP implementation process in Vietnam.

IT team in HCMC

HISP has employed a team of four full-time developers in HCMC (9.9). This team is located at the premises of the partner health centre in HCMC and is constituted by former students from the partner university in HCMC and OutSoft. Firstly, they are responsible for managing local requirements and developing functionality and adaptations. Secondly, they are intended to support the technical implementation of DHIS in HCMC and Hue, as well as perform training and support for end-users. The employees have been involved in DHIS 2 development and have a good overview of the system, and thus good qualifications for adapting the system quickly to the needs of the users. They also have good relations to the global HISP software development network and are able to communicate reasonably well

with other developers through the communication and coordination tools used in the project (ref. 6.2).

HISP coordinator

HISP has employed a local HISP manager and coordinator based at a medical university training centre. He is a medical doctor and has extensive experience from and contacts within the health system. His responsibility is to manage and coordinate the overall HISP effort in Vietnam.

Norwegian master students

HISP benefits from Norwegian master students connected to the project through their master thesis. As of September 2006, nine Norwegian master students have travelled to Vietnam to support implementation and development of DHIS. Three of these students including me have acted as core developers of DHIS 2. During the fall of 2006, three Norwegian students will be present in Vietnam.

Ministry of Health

The MoU with the Ministry of Health states that the last-mentioned organisation is responsible for finding a suitable IS developer intended to work with the DHIS and support the implementation first in Hanoi and thereafter in other provinces (ref. appendix C). MoH found one person who later withdrew from the project. No further action has been taken by the MoH to fulfil this agreement.

7.4.3 Local partners

In the following section I will account for HISP's partners in Vietnam.

Local university in HCMC

HISP is collaborating with the Faculty of Computer Science at a local university in HCMC (ref. 9.7). The faculty has an information systems group containing 10 students which participate as software developers for DHIS 2. The Vietnamese students use DHIS 2 as a research project and collaborate with Norwegian students at UiO. A UiO supported course at the partner university is scheduled for 2007.

Local medical university

The HISP coordinator in Vietnam is head of department for community health. He and two master students are supporting the DHIS implementation with a focus on health management. This university provides training facilities for larger training sessions with participation from all the districts in HCMC.

Local university in Hue

HISP is collaborating with the Faculty of Computer Science to let fourth year students do internship in the local HISP project, both with regards to end user support and software development. HISP has employed a graduated student that previously worked as an intern.

Public IT enterprise in Hue

HISP is collaborating with a public IT company that develops software for the local government. Norwegian master students have been based here while doing fieldwork. The company's role is to support the software development and implementation process.

7.4.4 DHIS 2 implementation process

The first phase of the DHIS 2 implementation process in Vietnam started in HCMC in April 2006 and lasted for one month. The intention of this phase was to get a realistic test of the DHIS installation package and to get feedback from health workers in a realistic environment. One health program and one health district in HCMC was chosen as a pilot district. Users were trained in one-on-one sessions in order to optimize the conditions for learning, feedback and building of user relationships. The state of the DHIS 2 was evaluated by the partner health program in HCMC, and eventually approved by the manager (ref. 7.3).

The second phase of the implementation was regarded as an expanded pilot phase. It started in May 2006 and lasted for three months. The pilot area was expanded with two more districts and two hospitals. Training and support activities were continued with courses and follow-ups at the premises. Manuals were created to support the training.

The third phase was started in August 2006 and aimed at installing DHIS 2 in all districts in HCMC. As of October 2006, DHIS 2 was installed and users were trained at 30 wards and hospitals. 27 out of these had started reporting data electronically upwards in the hierarchy. In HCMC, DHIS 2 was installed at the district and city level. The new working routines implied that personnel at the district offices received the paper based reports as earlier from the wards and entered the data into the DHIS 2 system. From there, the data would be exported to an XML file and sent to the city level for import. Feedback from the users has been good, and DHIS 2 is generally perceived as superior to the preceding DHIS systems. As of October 2006, the health department in HCMC is maintaining the paper based reports and the electronic reports in parallel. They have stated that if DHIS 2 proves to be sustainable and satisfactory; they will phase out the paper based reports in favour of the electronic reports. As of October 2006, there are plans for expanding the implementation effort to include one more health program in addition to the current pilot program.

<i>Phase</i>	<i>Period</i>	<i>Scale</i>	<i>Purpose</i>
First	April – May 2006	One health program in one district	Testing of installation package and getting feedback from real users
Second	May – July 2006	One health program in three districts and two hospitals	Testing in hospital environment
Third	August 2006 –	One health program in all districts; plans for one additional program in November 2006	Scaling up and getting system into production

Table 3: Overview of the DHIS 2 implementation process

8 Global software development within the HISP network

This chapter presents my contribution to the DHIS 2 system in general. Subsequently my development effort for a global DHIS 2 report module is elaborated. The development approach, requirements gathering, challenges and solutions that emerged and the implementation and adaptation process to the Vietnamese context are investigated.

8.1 *Getting in touch with HISP*

During the spring of 2005 I attended the course “Open source development and Java frameworks in global networks”. This course is based on the DHIS 2 software application, and teaches the various Java frameworks being used in the DHIS project. I enrolled this course because my main interest within IT is information system development in a Java environment in particular. After finishing the initial mandatory deliverables I was assigned to work with the core module of the DHIS 2 system. Even if my contribution to the system was minor during the initial period, I learned about the architecture, frameworks and technology being used. This experience turned out to be valuable when I at the end of the course was asked and agreed to continue working with the system and use it as a basis for my master thesis.

8.2 *My contribution to DHIS 2*

During the autumn of 2005 my skills and capabilities for contributing to the system improved, as I learned from my fellow core developers and from practical problem solving. In the following section I will describe my contribution to the DHIS 2 system.

Indicator store

In August 2005 I was given the responsibility for developing the indicator core functionality of DHIS 2. An indicator contains a formula which is intended to indicate the state of a medical phenomenon (ref. 6.3). I developed a service module which contains the object model and persistence functionality. Appendix A, section *Indicator store* explains this in greater detail.

Aggregation engine

In September 2005 I started working with the aggregation functionality. Aggregation in DHIS 2 means adding up or finding the average of registered data for multiple periods and/or sub hierarchies in the organization unit structure. This service was released along with the DHIS 2 light version in January 2006. It has been constantly altered in order to support various data types and to improve performance. Appendix A, section *Aggregation engine* explains further.

Data dictionary

In the first period of my field work in Vietnam I worked with the data dictionary web module. This module provides graphical user interface for handling of data elements and indicators. It

was originally intended to work, as the name implies, as a shared resource and means for standardisation of health metadata which could be utilized by other health information systems. With the exception of the handling of the indicator formula; the module was later improved and partly re-written by another core developer. It will be discussed later in this chapter and further illustrated in Appendix A, section *Data dictionary*.

Report tool

During my stay in Vietnam my development effort was mainly directed towards a report tool module. The intention of this module is to give health workers the ability to use their captured data and present it in a computerised report. This report can be designed to look exactly like their familiar paper based reports. The report module acts as a basis for this chapter and will be discussed further later on.

Datamart

In May 2006 I was assigned to develop a data mart. A data mart is kind of a data warehouse where data is aggregated and exported to dedicated tables in the database. There are several advantages of keeping a data mart. Firstly, one allows for external information processors as Excel pivot tables to be utilized. Such pivot tables can use databases as data sources, and provides a flexible and powerful means for data analysis. Secondly, data can be altered, re-formatted and processed without affecting the primary data storage. Also, it allows for data integration as several DHIS databases can be exported into one data mart. This functionality consists of a service module where the part of calculating registered data and inserting aggregated data into the data mart tables is being done. It also includes a web module where users are presented with alternatives for which data to export. This functionality is described in Appendix A, section *Datamart*.

Options module

In August 2006 I started working with a core service which would provide various user options. Firstly, it contains an option for selecting which property of the data elements and indicators is to be displayed, i.e. full name, short name, alternative name or code. This option is included because some languages which DHIS 2 is translated to contain very long names for medical phenomena. Secondly, it contains an option for choosing which property to use for sorting lists with data elements and indicators. This option was included since sorting by code is common practise in some of the countries where DHIS 2 is being used. This module is examined in Appendix A, section *options module*.

BIRT report viewer

The report tool is appropriate for designing exact reproductions of paper based reports, but is fairly limited when it comes to dynamic design of reports. The BIRT report framework (ref. 6.1.8) offers this kind of functionality, e.g. inserting lists of organisation units sorted by group in the report. Therefore a report module based on the BIRT framework was desirable as a supplement and alternative to the report tool module. The BIRT viewer module takes advantage of a pre-built web application which makes it possible to render reports with a set of parameters. Reports can be generated and displayed simply through an URL request to the mentioned web application. The BIRT report viewer module takes care of uploading report

designs and requesting the appropriate URL. This module is further explained in Appendix A, section *BIRT report viewer*.

Organisation unit management

My contribution to the organisation unit management module has been the implementation of the group set functionality. A group set is, as the name implies, a set of groups. A group set can be compulsory, i.e. all organisation units are required to be a member of one of the groups in the group set, and exclusive, i.e. organisation units can only be a member of one of the groups in the group set. This functionality is valuable and primarily used for analysis. An example of a compulsory and exclusive group set is “organisation unit type”, which has the members “rural” and “urban”. This functionality is elaborated in Appendix A, section *Organisation unit management*.

8.3 Report module development

In the following paragraphs I will account for the development of the report module which eventually was implemented as a part of DHIS 2 in the provinces of HCMC and Hue.

The purpose of a report module is to give the users the ability to create reports based on captured data from the database. The need of a DHIS report module grew out of the following conditions:

- A main reason for the failure of the DHIS 1.3 implementation in Vietnam was the lack of a working and suitable report generator. Without a report generator the users were unable to present their captured data and report to their superiors. This led to displeasure among the users and reduced motivation for using the system (ref. 7.1.3).
- The DHIS 1.4 version contained some limited reporting functionality, but this was not appropriate for the Vietnamese reports. The DHIS 1.4 version was scheduled to be implemented in Vietnam during my stay.
- The memorandum of understanding between the Ministry of Health and HISP from November 2005 stated that an open source Java based report generator was to be included in the software application suite intended to be implemented in Vietnam.
- The only existing working report module was developed by the HISP employee in Hue (ref. 7.2.4). As previously mentioned the disadvantages with this module were that the employee was the only person capable of designing the reports, which additionally was a very time-consuming operation.

These circumstances gave the development of a report module high priority. Two HISP students from Oslo had previously made an attempt to develop such a module but had given up before accomplishing it. This module was now in a semi-finished state. There had also been an attempt to create a report designer by a HISP student, but this module was abandoned and not ready to use.

8.3.1 Development approach

After discussing the situation with the project coordinator in Oslo we decided to try to use the semi-finished report module as point of departure for a new module. DHIS 2 contained an interface and implementation for communication against DHIS 1.4 datamart databases. We planned to connect the report module via the DHIS 2 API to the last-mentioned interface in order to be able to access the data in the datamart. This approach turned out to be less fruitful as both the report generator and the DHIS 1.4 bridge functionality were incomplete. Finishing these systems would require a lot of time which we at the moment could not afford to spend.

My next approach was to examine the desktop report tool created by the HISP employee in Hue. Firstly, this system required the user to design a report in iReport (ref. 6.1.7). Secondly, some standard parameters had to be selected in order to generate the report, i.e. a datamart database, a period, an organisation unit and a design file made in iReport.

iReport allows the user to display data in a report by adding a field or a parameter. A field is normally retrieving data from a database through a JDBC database connection with a SQL query. A parameter is simply a key-value pair which can be included in the report. The key-value pairs are supplied programmatically during runtime through a Java map (ref. Figure 7). iReport supports several additional data sources, e.g. a scripted SQL query against a database, a JasperReports data source, a CSV file and a Java bean collection.

The principle behind the mentioned report tool was to pull all data values from the user-supplied datamart database for the parameter combination of the given period and organisation unit. These values were made available to the report as parameters in a Java map, with the data element names as keys and the data values as values in each parameter map entry. If a parameter was included in the iReport design with a corresponding parameter name the value would be printed after generating the report.

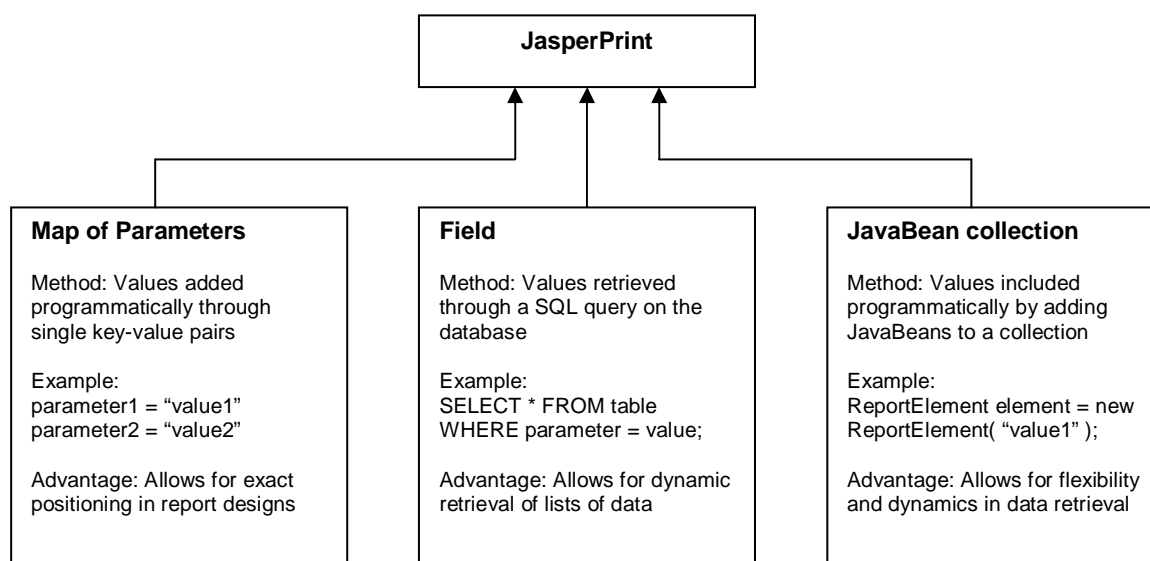


Figure 7: Overview of available data sources for JasperReport designs

Examining this system entailed two useful acknowledgements. Firstly, parameters are intended to be used for meta-data or static values, like the report period or a static figure. The system made all of the report data available through such parameters during runtime. This is not common practise but still a perfectly feasible solution. Report data is usually provided through a field. Secondly, the system provided me with complete and transferable code sections with e.g. database connection setup which probably would have taken me a long time to figure out on myself. These points gave me the idea of creating a report tool from scratch. I made a prototype with almost identical functionality as the previously mentioned report tool in order to get feedback and as a basis for a new module.

8.3.2 Requirements gathering

In the following paragraph I will describe my procedure for gathering requirements for the report module.

Discussions

During the development process I had several discussions with the HISP coordinator in Oslo. He has been involved in the HISP project for several years and has huge experience with the challenge of developing a report module among other from the first implementation effort in HCMC. Hence, he was able to inform me about several important requirements. He was also able to give peer reviews and general feedback to the functionality and the user interface regarding user friendliness and suitability.

Report analysis

Analysing the reports being used in the health provinces where the system was intended to be used was a natural source for requirements gathering. The HCMC and Hue health province used several reports at the district level and at the hospital and ward level. I managed to get hold of some of those reports through the Vietnamese students at the partner university. The HISP coordinator in Oslo provided me with reports from a HISP pilot district in India where the system was intended to be. Inspecting the report designs was valuable because the report module had to be able to generate exact reproductions of them.

Expert inquiry

During the workshop in December 2005, the HISP employee from Hue visited HCMC to work with me and the IT worker at the partner health centre (ref. 9.6.4). She was the person with the most extensive experience and knowledge about report generation with regard to DHIS as she had developed the report module previously being used in Vietnam. She provided me with general information concerning requirements of report modules such as report design.

Prototyping

Prototyping is a technique for building a quick and rough version of a desired system or parts of that system, and illustrates the capabilities of the system to users and developers. In the beginning of the report module development phase I made several prototypes as a means of getting improved feedback from the HISP coordinator in Oslo and other HISP developers. I

made prototypes for the user interface and for main functionality like database connections and JasperReports integration. The prototypes made it easy for the reviewers to visualise my ideas and come up with constructive feedback and suggestions for improvements. They also served as communications mechanisms to allow reviewers to understand interactions with the system. One drawback was that this approach sometimes gave the impression of the development process being further along than was actually the case.

I also used paper prototyping for gathering requirements for the user interface. Paper prototyping is favourable since it demands less work than code prototyping. I used these paper prototypes for discussions with the students at the partner university.

User feedback

Feedback from the end-users in terms of inquiries for new functionality, suggestions for improvements and exposure of flaws emerged during the DHIS 2 pilot implementation in HCMC. This kind of feedback was obviously fruitful with a view to local adaptation and led to iterative development cycles where new functionality was developed or existing functionality altered until the users were satisfied with the solutions. The health workers who were used to produce paper reports each month were particularly engaged. This situation was likely to be a result of the fact that the paper reports were the confirmation of their performance, and that they had not been accustomed to the idea of just exporting data upwards in the hierarchy.

8.3.3 Challenges and solutions

Below I will account for how I gathered the requirements for the report tool and the solutions I found to gratify them.

Simplicity

The HISP coordinator in Oslo emphasized that there was a need of a report designer which made it easy for health workers and advanced users to design their own reports. The previous solution of manually entering report parameters into iReport was unacceptable as it required extensive skills and was very time-consuming. Another drawback was that the system retrieved every available data value for the user-specified period and organisation unit, not only the values needed for the report. This made the memory footprint and time to generate a report unnecessary large. Eventually there would be lots of reports to make, and if the work of creating those reports could be delegated to local health workers it would free up a lot of time for HISP software developers.

An iReport design is backed by an XML file with the extension JRXML. This file represents the design with a human readable XML syntax, and is edited by iReport e.g. when the user adds elements to the report. My idea was to let the report tool manipulate such a file directly in a similar way during runtime. The user would select data elements and indicators needed for the report through a user interface. The report tool would write a JRXML file containing the selected report elements. The necessary data values would be retrieved from the database, put in a Java map and used to create the report together with the design file. After implementing this solution I asked the HISP coordinator in Oslo for feedback.

Report designer

The coordinator approved that the solution had revealed the user from the job of entering the report parameters manually. He emphasized that the module still required the user to drag and drop the parameters into the report design and create labels, headers etc. It would be unacceptable to let the regular health worker be responsible for maintaining this task as we could not expect them to maintain such skills. Therefore it was desirable to offer some standard report designs to cover the needs of inexperienced users.

To accomplish this task I decided to use the same approach as last time; i.e. manipulating the JRXML report design file directly. I decided to offer two simple report designs. The first had one column of data where the data values were listed right next to the corresponding report element name. The second was similar but with two columns of data. After examining the JRXML syntax I managed to create a method which displayed the selected report elements nicely on the report.

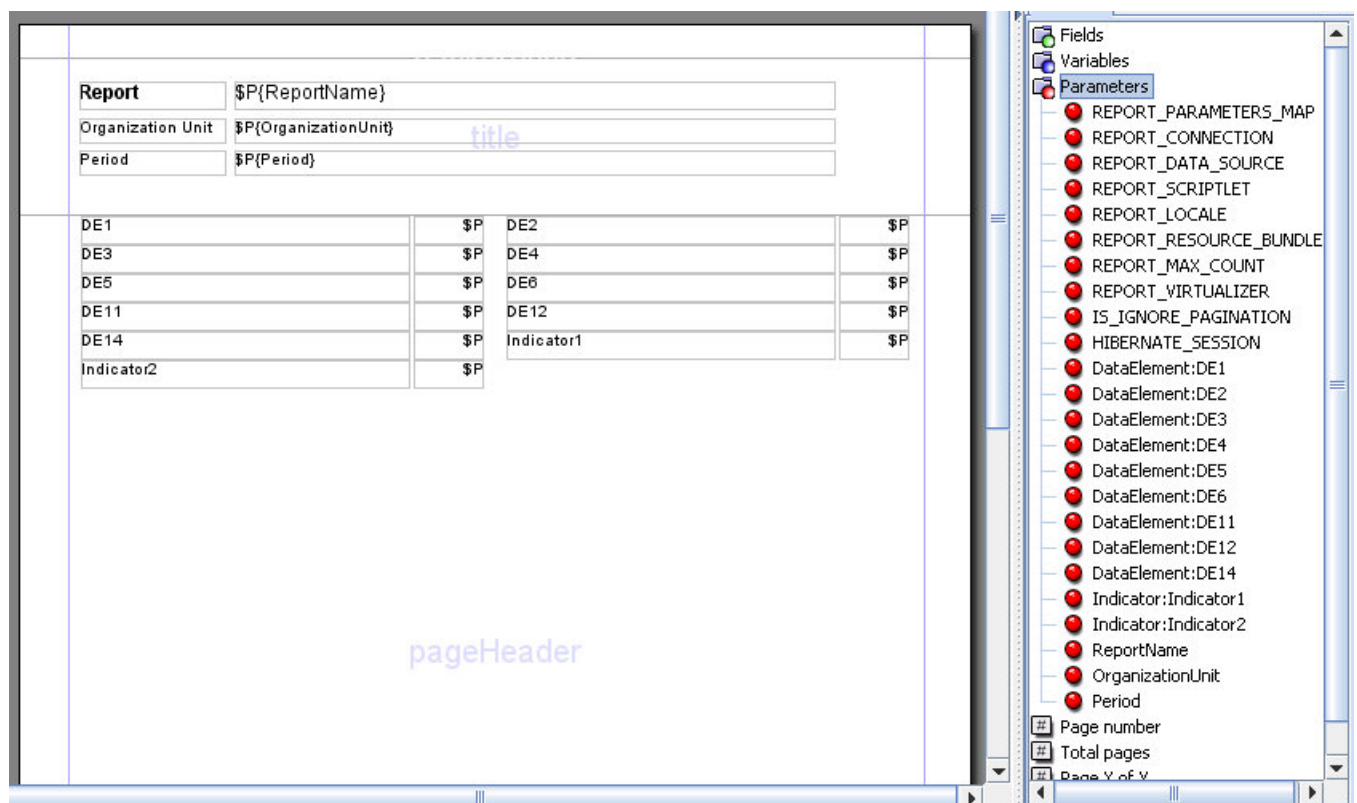


Figure 8: Section of the iReport user interface.

The available parameters can be seen in the right window in Figure 8. These parameters can be dragged and dropped to the report design in the main window. The current report design has 10 parameters each with a corresponding label text ordered in two columns.

```

<parameter name="DataElement:DE1" class="java.lang.String">
  <parameterDescription>
    <![CDATA[DataElement:DE1]]>
  </parameterDescription>
</parameter>

```

Code snippet 1: Declaration of a parameter in a JRXML design file.

Code snippet 1 demonstrates simple and easily understandable JRXML syntax. The name of the parameter is specified within the CDATA-tag. This name has to be equal to the key of the corresponding parameter entry in the previously mentioned Java map.

```

<textField>
  <reportElement x="216" y="1" width="44" height="18"/>
  <box topBorder="None" BorderColor="#000000"/>
  <textElement textAlignment="Right" lineSpacing="Single">
    <font fontName="Arial" pdfFontName="arial.ttf" size="10"/>
  </textElement>
  <textFieldExpression class="java.lang.String">
    <![CDATA[${P{DataElement:DE1}}]>
  </textFieldExpression>
</textField>

```

Code snippet 2: Positioning of a parameter in the JRXML report design file.

The JRXML syntax allows for specifying the exact position, width and height of a parameter, as well as several other options like font type and size.

Report	report
Organization Unit	OrganizationUnit1
Period	2006-01-01 - 2006-02-01
DE1	10 DE2 20
DE3	30 DE4 10
DE5	20 DE6 30
DE11	10 DE12 20
DE14	30 Indicator1 -1,0
Indicator2	400,0

Figure 9: Section of the report from Figure 8 generated as a PDF file.

Reusability

The previously mentioned solution gave inexperienced users the ability to make simple report designs and advanced users the opportunity to create customised reports. The module had a weakness when it came to the ability to reuse the reports, as the users had to select the elements for the report each time it was generated. This was inconvenient when dealing with large reports, and required me to find a way to persist the report elements belonging to the report.

To solve this challenge I decided to save the report elements and the selected report design template used in the JRXML file to an XML file. I used the xStream library (ref. 6.1.9) for serializing the information to XML. These XML-files were written at the same time as the JRXML-files. After designing a report it was now possible to select it, enter the desired period and organisation unit before generating it. The system was automatically looking up which report elements, e.g. data elements and indicators, being included in the report and retrieving the correct data values. Any adjustments made to the report design JRXML file would be reflected in the corresponding XML file.

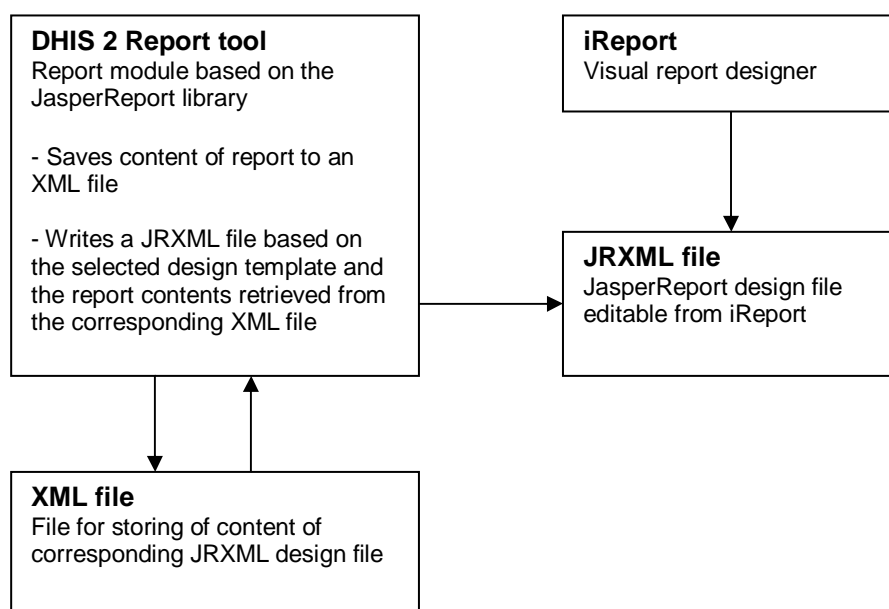


Figure 10: Conceptual overview of the relationships in the report module

Interoperability

At the time the report tool was only able to use data from a DHIS 1.4 datamart database. As the long term plan for Vietnam was to replace DHIS 1.4 with DHIS 2 it obviously needed to be applicable to the last-mentioned system as well. This was vital as both systems lacked satisfactory reporting functionality.

My first suggestion was to maintain two separate versions of the system; a version for DHIS 1.4 and a version for DHIS 2. This was turned down as it would double the maintenance workload and was a less elegant solution. My next idea was to insert a data access layer in the

application. I created an interface which could have different implementations for DHIS 1.4 and DHIS 2.0. The *inversion of control* abilities of Spring (ref. 6.1.3) made it easy to switch between implementations at compile time. The system retrieved data from the database at several different places in the application layer. All necessary methods for data retrieval were included in the data access layer and occurrences of code directly accessing the database was replaced with references to the corresponding method in the data access layer. In order to connect to an underlying database it was now sufficient to make an implementation of the report data access interface and do a minor change in the Spring configuration file.

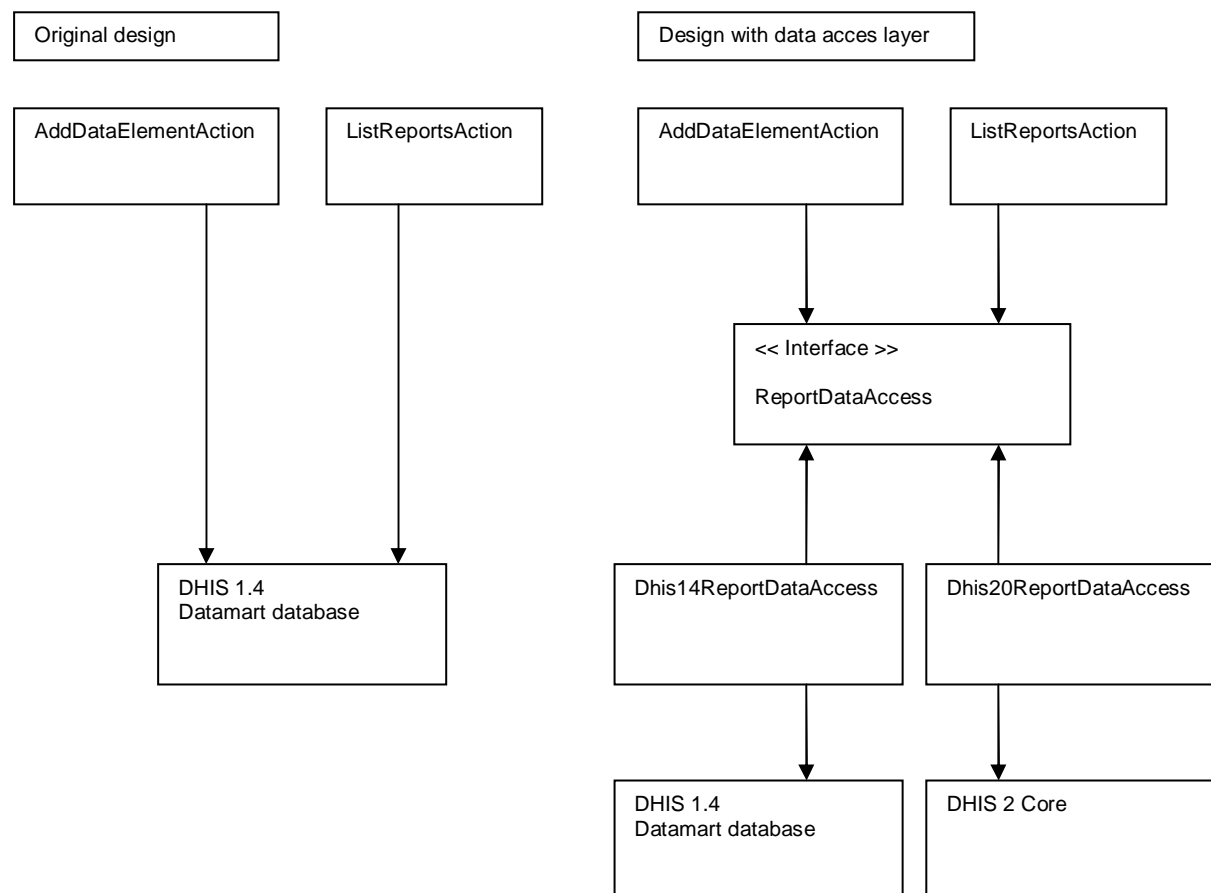


Figure 11: Brief object diagram of the report module

Charts

A requirement for charts in the report designs emerged during discussions with health managers in HCMC. After exploring the JasperReports documentation I learned that JFreeChart (ref. 6.1.6) can be embedded in reports only by including the library to the class path. I added support for chart elements equivalent to report elements in the backing report XML file and edited the JRXML design files directly during runtime. The JRXML syntax for representing charts is easily understandable and simple to manipulate in order to get the desired appearance.

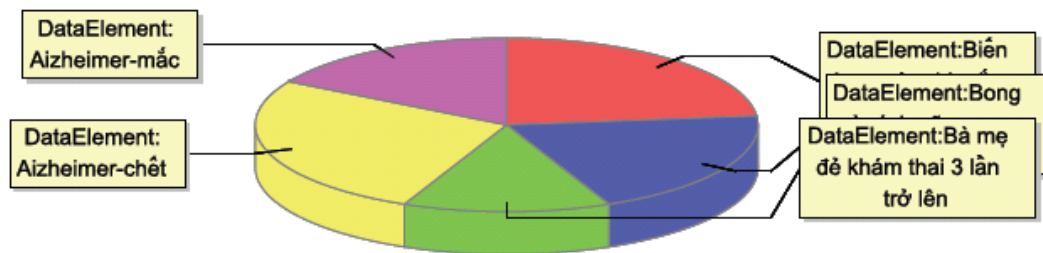


Figure 12: Pie chart with Vietnamese report elements generated by the JFreeChart library.

Flexibility

Examination of several paper report forms in use in the HCMC and Hue provinces revealed that there was a need of more flexible selection of data. One report used in Hue needed to list all child units of a main organisation unit together with the corresponding data values. Another report used lists of every data element in a data element group. Additionally, the HISP coordinators in Oslo wanted to emphasise the advantages of computerised reports by allowing a general flexibility in the data selection. They requested i.a. the possibility for including in the report data values for all data elements in a data element group and data values for all organisation units in an organisation unit group for a given data element. Computerised reports from an electronic health information system entail vast advantages compared to paper based reports in terms of analysis. Data can be compared and aggregated in a number of fashions not tied to a pre-defined standard as is the case with the paper reports.

These requirements revealed a weakness in the report parameter approach. The approach had turned out to be effective for exact reproduction of paper reports because each report element could be exactly positioned on the report. This would not be possible when data was retrieved with regular database queries. On the other hand it did not allow for inserting flexible lists of report elements retrieved in a database query directly in the report, as the items of such lists had to be added as report parameters one by one. This limited the support for such dynamic data insertion.

Design conflict 1: Ability for exact positioning of elements in reports vs. dynamic retrieval of data

At the time, the report module only supported reports that included one period and one organisation unit. The user was prompted to enter the period and organisation unit for which to generate the report. This was favourable since the report could be reused and generated for all desirable combinations of periods and organisation units. Still, many reports contained data values for multiple organisation units or periods: One report from Hue province

contained data values for all child units of the main organisation unit. One report from HCMC province contained data values for one period together with the values for the equivalent period last year.

Design conflict 2: Reusability of reports vs. support for several organisation units and periods

SỞ Y TẾ TP. HCM
BỆNH VIỆN Hung Vương

CỘNG HÒA XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

BÁO CÁO HOẠT ĐỘNG CHƯƠNG TRÌNH BVSKBMTE - KHHGD
Tháng 09 (Từ ngày 01/09/2005 đến ngày 30/09/2005)

I/ KẾ HOẠCH GIA ĐÌNH :

1. Dụng cụ tử cung :

- Tổng số DCTC đặt / 364 /
- Thời điểm đặt :
 - * DCTC đặt sau kinh / 166 /
 - * DCTC đặt sau mổ / 0 /
 - * DCTC đặt sau nạo hút ĐHKH / 198 /
- Phân loại :
 - * TCu 380 / 364 /
 - * Multiload / 0 /
 - * DCTC khác / 0 /
- Số tháo dụng cụ tử cung : Tổng số / 87 /
 - + Vô kế hoạch / 0 /
 - + Rơi DCTC / 0 /
 - + Thay DCTC / 30 /
 - + Rong kinh / 0 /
 - + Viêm / 0 /
 - + Đau bụng / 0 /
 - + Khác / 66 /

2. Triệt sản

- Tổng số / 39 / + Thành phố / 24 / + Tỉnh khác / 15 /
- Trong đó
 - * Triệt sản nam / 0 /
 - * Triệt sản nữ / 39 /
- Tai biến : Không có

3. Thuốc tránh thai

- Thuốc uống : * Số người được cấp : / 31 /
- Thuốc tiêm : * Số người được tiêm : / 0 /
- Thuốc cấy : * Số người được cấy : 02

4. Bao cao su

- * Số người được cấp / 0 /

5. Số hút ĐHKH - Nạo thai :

- Tổng số / 1265 / + Thành phố / 1146 / + Tỉnh / 119 /
- Phân tích tuổi thai :
 - * ≤ 6 tuần / 48 /
 - * Từ > 6 đến ≤ 8 tuần / 54 /
 - * Từ > 8 đến ≤ 12 tuần / 899 /
 - * > 12 tuần / 464 /
- * Phẫu Thuật Nội Khoa : 579

Figure 13: Scan of the first page of a paper report used by the HCMC health province.

Implementing support for multiple organisation units could easily be done by including the organisation unit ID in each report element, in other words linking each report element to a specific organisation unit. The dilemma was that this forced the user to make individual reports for each organisation unit intended to use it. Still, in a health district with fairly limited number of wards and hospitals this might be an acceptable solution. Support for multiple periods could be implemented in a similar way. Nevertheless, making one report for every period was obviously an unacceptable solution.

Even if this was not an ideal solution, I decided to implement support for organisation unit specific reports able to contain multiple organisation units in addition to the existing generic report. This report type was advantageous because it allowed for several organisation units in a report, but implied a drawback since it had to be re-designed for every unit intending to use it.

8.3.4 Implementation and adaptation to local contexts

The report tool was included in the installation package at the beginning of the DHIS 2 implementation in HCMC and Hue provinces in June 2006. As of October 2006, the software is installed at two pilot district offices and two hospitals in HCMC and five districts in Hue. An implementation process covering every health unit in both cities is being planned. The employed Vietnamese students in the support and development group (ref. 9.9) in HCMC received frequent feedback from health workers using the system in their daily work. Feedback on the report module was fairly good, and the current functionality worked as expected. Still requests for new and extended functionality were emerging rapidly. In the following section I will account for the new requirements and solutions.

Vietnamese special characters

The employed HISP students designed the reports for the health department in HCMC. When the reports were generated it turned out that the Vietnamese characters did not render properly, as special Vietnamese character were displayed as question marks.

DHIS 2 is intended to be implemented in countries with non-standard languages like Vietnam and India. This is the reason why databases used in connection with DHIS 2 are set up with UTF-8 character encoding. A character encoding scheme is a way of mapping a character to a number in a character set. The most common schemes, e.g. US-ASCII, use only one byte for storing each letter, which is sufficient e.g. for the English alphabet. On the other hand it is highly insufficient for encompassing the characters in all written languages. UTF-8 uses a multi-byte encoding scheme extending US-ASCII and is the most common character encoding for Unicode. Unicode is an industry standard designed to allow text and symbols from all of the writing systems of the world to be consistently represented and manipulated by computers.

After examining the report module it turned out that the system was writing and reading the backing XML files using ASCII encoding. The solution to the problem with the Vietnamese characters was to write and read those files using UTF-8.

Exact replications of existing paper based reports

A highly emphasised requirement from the health department regarding the report module was its capability to create exact reproductions of the existing paper based reports. This need was apparently based on the symbolic value of these reports. The reports acted as a confirmation of the work undertaken by the health workers. By delivering the reports e.g. each month, the health workers had documented and affirmed their work. This requirement was inconsistent with the incentives with computerised health information systems in terms of analysis of data, but necessary in order to satisfy the health department.

To cover for this requirement I implemented an option where the user could, instead of creating the report immediately after the design phase using one of the standard report designs; generate only the JRXML report design file. The last-mentioned alternative made it possible to open the generated JRXML file in iReport and do further adjustments, e.g. alter the report until it looked similar to the paper based reports. iReport was a suitable tool for this task as it offered functionality for creating detailed and customised reports. The user would not have to start from scratch as the report parameters were available and included in the report and could be moved to the desired location.

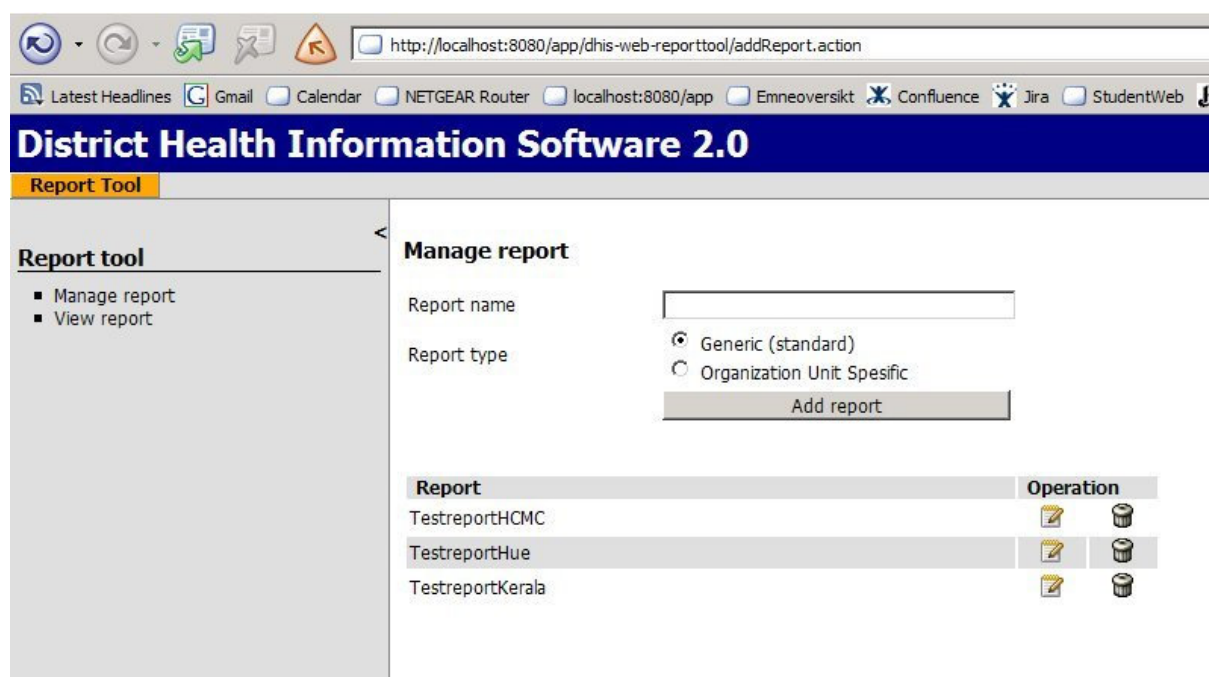


Figure 14: User interface in the report module for report management.

Child organisation units

The report used by the partner health program in Hue contained several data elements for an organisation unit. In addition the report displays the same values for every child organisation unit of the main unit. This entailed that the HISP employee responsible for designing the Hue report had to manually enter parameters for each combination of data element and child organisation unit. In addition he had to make one report for each district in Hue. This implied a total number of several thousands report elements and a heavy workload.

The report tool supported in the first place only one organisation unit per report, but was later modified to support several units. To relieve the person responsible for making the Hue reports for the heavy workload I made a function for automatically including report elements for every child unit of the selected organisation unit.

TÌNH HÌNH CHĂM SÓC SỨC KHOẺ BÀ MẸ																				Biểu số 10													
Đơn vị báo cáo:		Thành phố Huế								Thời điểm:										2006-08-01 - 2006-08-31										Trang 1			
TT	Cơ sở y tế	Tổng số lần khám phụ khoa	Tổng số người khám phụ khoa	Tổng số cặp vợ chồng chờ sinh	Số mới phát hiện có thai trong kỳ	Lần khám			Số phụ nữ được tiêm phòng UV2+	Lần khám thai						Số bà mẹ đẻ không do cán bộ y tế đỡ đẻ thường	Mổ đẻ	Fao-xếp	Khám sau đẻ		5 Tai biến sản khoa												
						Tổng số	Trong đó khám lần đầu	Tổng số đẻ		T. đo khám thai trên 3 lần	Nơi đẻ				Tổng số bà mẹ				Trong đó khám tuần đầu	Bảng huyết		Sân giật		Nhiễm trùng		Uốn ván		Vỡ tử cung					
											CSVT nhà nước	CSVT tư nhân	Tại nhà	Nơi khác						Mắc	Chết	Mắc	Chết	Mắc	Chết	Mắc	Chết	Mắc	Chết				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		
	Tổng số	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1	Bệnh viện tp Huế	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2	Phường An Cựu	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
3	Phường Kim Long	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
4	Phường Phường Đức	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
5	Phường Phước Vĩnh	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
6	Phường Phú Bình	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
7	Phường Phú Cát	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		

Figure 15: Report for partner health program in Hue.

Reports with multiple pages

Some reports used in Hue province turned out to contain several pages. Instead of making one report per page the HISP employee dealing with the implementation in Hue wanted to be able to generate the whole report at once in order to decrease the workload. As this was a special requirement from Hue district he decided to make his own branch version of the module, where he implemented functionality for multiple pages.

Even if this solution pleased the Hue health district it entailed unnecessary complexity as two modules now had to be maintained. Another unfavourable aspect was that the mentioned functionality was likely to be needed in other places as new requirements were discovered during the DHIS 2 implementation throughout HCMC and Hue and in other countries as well. After discussing with the HISP employee he agreed to incorporate this functionality in the trunk version of the report tool.

Several periods within a report

One report used in Kerala, a HISP pilot health district in India, contained several periods. The report aimed at collection data at a monthly interval as well as comparing the registered value with the value from the corresponding month the previous year.

In order to cater for this requirement I made an option for creating a separate report type where the period identifier was included in every report element. Still this solution faced the same dilemma as with the requirement for several organisation units; the user would have to create one report for every period, which is in most cases unacceptable. The solution to this problem would be to provide the user with a dynamic form for entering the periods used in the report. This functionality has as of October 2006 not yet been implemented.

MONTHLY REPORT FOR SUB-CENTRE / URBAN HEALTH POST / REVAMPING CENTRE (REPORT OF ANM / MPW (MALE))

- | | |
|---|---|
| 1. State : KERALA | 7. Reporting for the month of : Jun-05 |
| 2. District : Thiruvananthapuram District | 8. Eligible couples (as on 1st April of the year) : |
| 3. PHC : Venganoor PHC | |
| 4. Sub Centre : FWC Mangalathukonam | |
| 5. Population of PHC : 0 | |
| 6. Population of Sub-centre : 4986 | |

II. Services

Sl. No.	Services	Performance in corresponding month last year	Performance in the reporting month	Cumulative performance till corresponding month of last year	Cumulative performance till current month
1.	Ante Natal Care				
1.1	Ante Natal cases Registered				
	a) Total	0	6	0	18
	b) Less than 12 weeks	0	3	0	8
1.2	No. of pregnant women who had 3 check-ups	0	7	0	14
1.3	Total No. of high risk pregnant women referred	0	1	0	3
1.4	No. of TT doses				
	a) TT1	0	6	0	16
	b) TT2	0	5	0	14
	c) Booster	0	2	0	2
1.5	No. of pregnant women under treatment for anaemia	0	0	0	0
1.6	No. of pregnant women given prophylaxis for anaemia	0	0	0	6

Figure 16: Report with several periods from Kerala state, India

8.4 DHIS workshop in South Africa

In September 2006 I attended a HISP workshop in Cape Town, South Africa. The workshop was an effort to gather developers from multiple HISP nodes, i.e. Mozambique, Ethiopia, Vietnam, India, Norway, and South Africa. The main intention of the workshop was to bring the developers using both DHIS 1.4 and DHIS 2 closer to the respective core developers of the systems, i.e. the DHIS 1.4 senior developers in Cape Town and the Norwegian master students from UiO, including me.

The development teams were entitled to having presentations of locally developed modules, to which they got feedback from the senior HISP developers and coordinators. The various developers got the opportunity to communicate face to face with the core developers, and give feedback and express requirements and needs directly to them. This close collaboration entailed precise communication and short response time regarding development of new and desired functionality.

Also, the workshop was favourable with regards to feedback on the report module. Several suggestions for improvements of the user interface were provided by the Vietnamese and Indian developers. Another aspect of the workshop was to give the usually busy developers the opportunity to focus merely on development, and to boost morale as meeting fellow developers face to face is pleasant when day to day communication takes place only on mailing lists.

Secondly, the workshop was intended as a preparation for an upcoming HISP conference in Eastern Cape, a province in South Africa. This conference would bring together not only developers but medical professionals from the various provinces utilizing DHIS. This would be a technical based conference with focus on strategic decisions regarding the DHIS systems.

9 Building an independent software development team

This chapter will discuss HISP's efforts for building a software development team in Vietnam, and is to a large degree based on my field study in Vietnam from the beginning of November 2005 to the middle of January 2006. I will explore the Vietnamese infrastructure, the capacity building process, the collaboration with a partner university in HCMC, communication problems and the eventual employment of the Vietnamese students.

9.1 Background

Building a health information system is a time consuming task and requires a great deal of work. From the beginning in 2004 DHIS 2 has been developed mainly by master students who use the software as a basis for research. There has also been occasional contributions from students attending the course “Open source development and Java frameworks in global networks” at the University of Oslo. A main challenge with this approach is the huge amount of training required to enable a student to contribute as a developer in the project. This entails the core developers having to spend a lot of their time teaching the new students. After the period of training the students have a few months before they finish the course, where most of them terminate their efforts regarding DHIS 2. This approach for DHIS 2 development is in other words not favourable with regards to productivity and efficiency.

The implementation of DHIS 1.3 in Vietnam started in November 2004 (ref. 7.1). A main challenge in this process turned out to be requirements management, which suffered from the vast distance between Norway and Vietnam and the lack of support personnel in Vietnam (ref. 7.1). The DHIS 2 was intended to be implemented in Vietnam during 2006. For this system to be appropriate in a Vietnamese context it was crucial for HISP to establish closer contacts with the end-users in order to clarify the local requirements. Developing the system solely with developers situated in Oslo would obviously be difficult.

Because of these matters the HISP leaders decided to try to establish a more permanent development team in Vietnam. The short-term plan has been to get a student group in Vietnam equivalent to the Oslo group to start developing DHIS 2. The more long-term plan has been to employ some of these students after they had been fully trained. These students should focus merely on code production and development of the DHIS 2. HISP is a university-based non-profit organisation with a relatively low budget, and not in position to pay expensive consultants in order to get the work done. With this in mind, establishing this team in a so-called low cost country like Vietnam would be preferable.

The initial plan was to use the DHIS 1.3 implementation as means for gathering local requirements. By using DHIS 1.3 as a prototype application many obstacles could be resolved and an overview of the local requirements and demands could be achieved. With this approach the subsequent DHIS 2 implementation could benefit from the previous experiences and avoid common pitfalls. The knowledge of the local context could possibly result in fruitful development processes and entail a faster integration and adoption to the Vietnamese context.

9.2 First collaborative effort in Vietnam

In January 2005 HISP made an agreement with a large outsourcing company in Ho Chi Minh City (HCMC) in Vietnam (from now on referred to as OutSoft). The agreement had several objectives. HISP would dispatch a Norwegian master student to HCMC to take the role as a team leader for a group of four interns at OutSoft. These interns were bachelor students in their last semester from two different universities in HCMC. The group was intended to work as a regular development team integrated in the day-to-day work at OutSoft. A manager at OutSoft would be assigned responsibility for the group, and the Norwegian student would report and coordinate the efforts with him. The interns had two main tasks: to participate in the DHIS 2 development and to support the ongoing DHIS 1.3 implementation in HCMC. The Norwegian student was supposed to guide them with DHIS 2 development, while another OutSoft employee was going to support their efforts regarding DHIS 1.3.

The interns were given different tasks related to DHIS 2. One employee was going to work on a patient record module that was requested by representatives of the local pilot project. Two of them were going to work on a web portal for reports; a place to publish and request generated reports on the Internet. The last one was going to assist another Norwegian master student with a report designer for the DHIS 2. The intention was that they should do all parts of the development themselves, including requirements gathering, design and interaction with potential users.

9.2.1 Training

The four interns had mixed experience with both object-oriented programming and Java, and the need for extensive training and support soon emerged. The Norwegian student ran lectures covering the frameworks and technologies being used in the DHIS 2 project. The interns were responsible for studying and practising Java on their own. OutSoft had extensive internal training programs for their employees which the trainees followed. As a part of OutSoft's training program the Norwegian student organized courses about the DHIS technologies where everybody could sign up as a concession for their services. The Norwegian student and the four interns were placed together in one of OutSoft's office landscapes, which made it possible give support at any time.

9.2.2 Project work

The OutSoft managers, HISP coordinators and the Norwegian student worked out a road map with scheduled milestones with a view to the interns' work tasks. This roadmap was made to make it easier both for HISP to follow the work progress and for OutSoft to evaluate HISP's effort inside the company. The interns delivered weekly reports to the Norwegian developer who used these to report to the responsible manager at OutSoft. Weekly meetings were arranged to discuss the progress and the performance of the development team. This routine was working well during the first couple of months, but faced severe communication problems and eventually more or less fell apart. The Norwegian developer later identified three main reasons for this breakdown:

- The manager responsible for the HISP effort had the main responsibility for another project that was experiencing major problems and required a lot of his attention. He was already over-worked and as a consequence of this he downgraded the HISP project. Later he was moved to another position, which practically ended the coordination effort.
- HISP only partially participated in the selection of two of the four interns. The other two was picked by OutSoft and assigned to the project. There were uncertainties among the interns regarding whom they were supposed to report to and who were in charge of the project. This problem was faced too late.
- The Norwegian developer had no previous experience with professional software development and found it difficult to quickly adapt to the strict routines employed at OutSoft. He felt the meetings with the manager were only for reporting the progress and that little feedback was given.

Even though the coordination with OutSoft more or less fell apart, the project continued as normal in the development group. The interns worked on their tasks and were followed up by the Norwegian developer, although problems with reaching the deadlines were experienced. The interns required a lot of support to be able to get progress, and it became obvious that they had great problems coping with the technologies used in the project. They expressed that they were not used to solving problems on their own without strict guidelines and requirement specifications. Severe communication problems were faced as only two of the interns had adequate English skills. Because of the obvious support capacity constraint of the single Norwegian developer the interns were requested to study documentation on their own. As almost all computer documentation is written in English this was hard for the interns with poor English skills to comprehend.

The two interns working on the report portal were not able to finish a working module by the end of five months. One of them was not able to learn the technologies used in the project, and was eventually transferred to work with the implementation of DHIS 1.3. The last intern in the group had therefore problems finishing the portal, and delivered only a partially working module. The intern working on the patient record module delivered a working module with a lot of the requested features. The intern helping out with the report designer module gave the impression of not being interested in the project at all, and aimed at developing software for her own use in her thesis. After considering the situation with the responsible manager at OutSoft it was decided that she would be left out of the project.

The four interns were placed in a setting with three objectives. They were required by their universities to deliver a thesis based on their work, HISP required them to develop modules for DHIS, and the internship provided them with an opportunity to get a job in the company. According to the Norwegian developer this lead to a dilemma for the interns as they to some degree had to prioritise their effort. Nevertheless, except for the last-mentioned intern, this did not represent a major problem for the project.

Even if the interns at OutSoft were at a high technical level and selected from the best universities in HCMC, they still needed extensive training in order to be able to contribute. As a result the development done by the interns during the first five months did not turn out to be very constructive for the DHIS 2 project. Early meetings with the management of OutSoft indicated that they wanted a continuous partnership with HISP, and as a part of this, HISP

would get the opportunity to employ a few of these interns after the initial five months. HISP had the impression that these former interns should be hired by OutSoft, with HISP paying their salary. This made the effort potentially valuable for HISP, which would be able to pick the best of the interns and let them continue their work and eventually finishing the modules they had started on.

A problem regarding the collaboration between HISP and OutSoft was the attitude to proprietary, and especially Microsoft, technologies. The management and the trainees at OutSoft were reluctant regarding these technologies and preferred working in a Java environment. The company's official policy was to stick to free and open source technologies. This was a major obstacle with a view to engaging these trainees as support personnel in the ongoing DHIS 1.3 implementation, which is based on Microsoft Access. Additionally they were not very enthusiastic regarding working with user support, as they preferred programming and system development.

9.2.3 Failure to establish a partnership

At the time the internships were about to end, HISP sat down with OutSoft to discuss the possibility to continue the collaboration. HISP was satisfied with the work which two of the interns had done and wanted them to continue working with the project. HISP was also prepared to send more students from Norway to be placed at OutSoft. OutSoft had earlier indicated that they wanted to strengthen their research and development department and they saw collaboration with HISP as a good opportunity for this.

At the time OutSoft was not satisfied with the progress of the DHIS 1.3 pilot project running in HCMC. They felt that the resources they had spent on this were not coming to a satisfying use. The major incentive for OutSoft to take part in the project was to eventually get in a position where they could provide commercial services around DHIS. They had lost faith in this as they considered the DHIS 1.3 pilot project to be progressing too slowly. They therefore announced that they would withdraw the employee they had put aside to work with the pilot project, arguing that their resources were becoming limited. A growing demand from their customers put them in a position where they were unwilling to spend resources on projects that did not bring back revenue. The lack of resources was also the reason why they had decided to down-size the research and development department dramatically. Additionally the manager was disappointed with the fact that the research and development department not had exploited the working power of the Norwegian developer while he was located at the company.

OutSoft argued that HISP had misinterpreted the agreement with the interns, stating that they had never agreed on HISP only paying cost price for their services. They offered HISP to hire the interns at the normal rate with a minor discount. This was unacceptable for HISP, as it was both contradictory to the initial agreement and economical impossible with the limited budget HISP had for the Vietnam project. The collaboration with OutSoft ended contemporary with the Norwegian student's departure from Vietnam in June 2005.

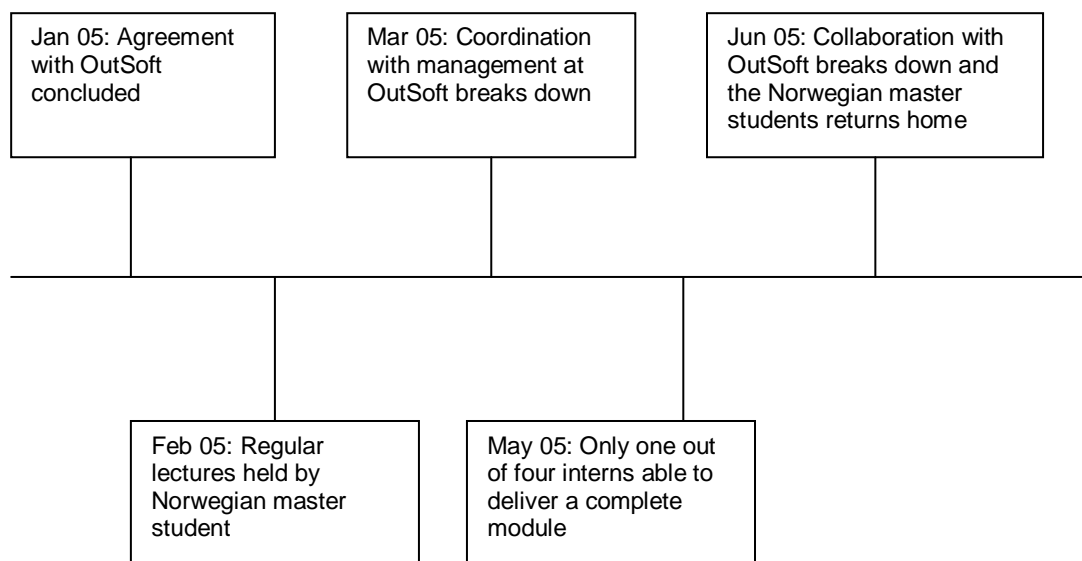


Figure 17: Timeline with major events during the first collaborative effort

9.3 Second collaborative effort in Vietnam

In 2005 HISP made an agreement with a local university in HCMC. The agreement implied that UiO and the Vietnamese university would exchange students and establish a professional cooperation regarding the development of DHIS 2. Establishing a partnership with the university in Vietnam was favourable for HISP for several reasons:

- The impending DHIS implementation in Vietnam required HISP to allocate human resources in the country. Norwegian exchange students doing fieldwork for their master thesis in Vietnam could be used to support DHIS development and implementation. Additionally, they could initiate and eventually accomplish a process leading to the establishment of a software development team consisting of fully trained Vietnamese students.
- The partner university has declared an “open source profile” meaning that the IT department focuses on free and open source technologies in their curriculum. As the DHIS project is exclusively based on free and open source technologies and frameworks, this entailed a set of common interests.

9.4 Summary of key actions

Figure 18 shows a short summary of the key events for the period I stayed in HCMC in Vietnam, i.e. November 1. 2005 to January 16. 2006.

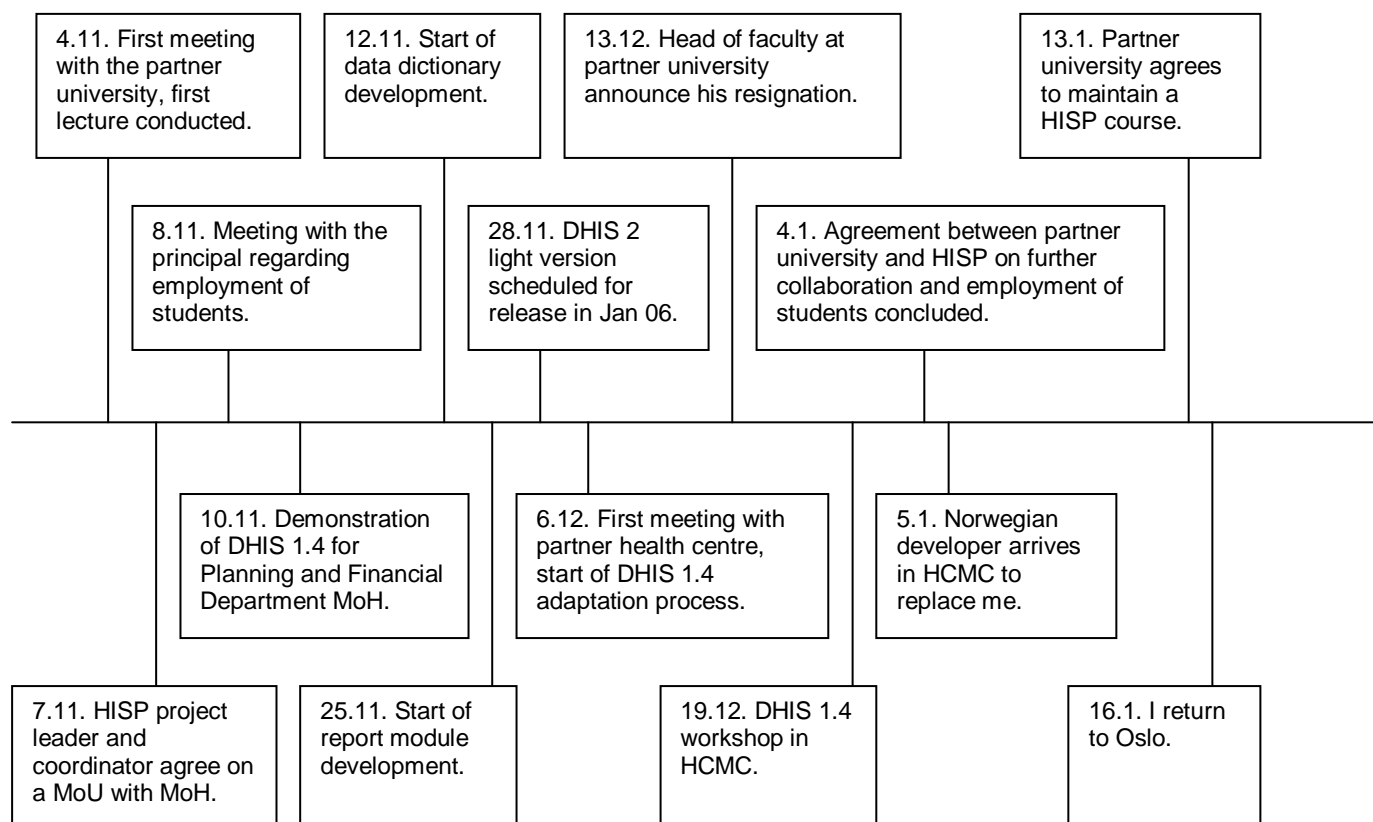


Figure 18: Timeline with major events during my field study in Vietnam

9.5 Infrastructure

Vietnam qualifies as a developing country when looking at infrastructural issues like transport, electricity and telecommunications. During my stay I encountered several problems related to infrastructure. In the following section I will describe the IT infrastructure at the partner university, the transport infrastructure, communication and solutions to infrastructural problems that emerged.

9.5.1 IT infrastructure at the partner university

The IT department at the partner university was equipped with one computer room containing 30 computers. These computers were fairly modern Pentium 4 computers donated by a Belgian university in 2003. The building had two larger rooms used for lecturing. These rooms were equipped with benches and desks of wood and had no air-conditioning. The lecturer's presentation facilities consisted of a microphone, a karaoke-like loudspeaker standing in one corner of the room, a laptop and a video projector. Most lectures were attended by about students in classes of about 150. Heavy resonance and a temperature of about 30 degrees entailed negative effects on the conditions for teaching and learning.

The HISP student group at the university accessed a working room with air conditioning and internet connection. Two of the students possessed modern personal laptops. One student used his desktop computer, which he had to transport on his motorbike to and from school every day. Usually two or three students worked together on each machine. All of the computers were running pirate versions of Windows XP. Pirate versions of computer software can easily be obtained in Vietnam, and most people can not afford legal copies. According to a report from Sida in 2004 94 % of all Windows installations in Vietnam are piracy versions. Most of the students' computers were running slowly as they had not installed firewalls or anti-virus software. In addition the students were not able to apply patches and updates from Microsoft because of their not genuine Windows versions.

The power supply at the university was quite unstable. The power went down several times every day, but mostly returned after some time. This impeded the progress of the work, as the desktop computers and internet connection went down. The internet connection was slow and unstable at an average download speed of about 10 kb/s. These factors implied poor conditions for software development. This applies in particular to distributed open source software development as it disturbed the use of tools like Maven and Subversion that depends on a stable internet connection.

9.5.2 Transport

The partner university is located about 30 kilometres outside HCMC. The hotel I stayed at is located close to the city centre. To get to the university I first had to travel through the city during rush hour and then 30 kilometres on a highway. The first weeks I travelled on the back of the motorbike of a student living in HCMC. I considered this as both dangerous and noxious, and convinced my friend to take the bus with me. My travelling time was 55 minutes in total to get to the university, and one hour and 25 minutes to get home. The roads were bumpy and in poor conditions and gave no opportunity for working at the bus. This implied a lot of futile working time.

9.5.3 Language issues

Most of the Vietnamese students spoke English, but their pronunciation was heavily influenced by Vietnamese. In the beginning it was difficult for me to understand, but after a few weeks I had memorized many of the Vietnamese twists of English words. The students with good English skills were good at assisting the students with poorer skills in situations where they did not comprehend what was being said.

9.5.4 Practical solutions to infrastructural problems

The poor internet connection at the university made it difficult for the students to check out or update their local code repositories. The files from the central Maven repository were downloaded at a speed of approximately 3 kb/s, which is extremely slow. The external libraries included in DHIS 2 amounted to nearly 300 mega bytes. Because of the frequent power failures and the slow download speed this would have taken an unreasonable long period of time to download. None of the students had accomplished this, which resulted in them not being able to compile the source code.

The solution to this problem was to burn my local repository at my computer to a CD and let the other students copy the content over to their computers. When new and large libraries were included I downloaded them at broadband internet cafés in the city and repeated the process at the university. The students were then able to continue development despite the limited internet connection.

To cope with the poor internet connection at the university and the great travelling time I decided to stay in the city centre two days a week. The area in HCMC where I lived had a high frequency of internet cafés. These cafés charged close to nothing for their services, provided a stable and fast internet connection and gave me the opportunity to connect with my own laptop. Another good place to work turned out to be a restaurant close to my hotel. The restaurant's first floor had wireless internet connection and tables suitable for working. The internet connection was stable and fast at about 50 kb/s. This place provided me with both good food and working conditions. Some times the Vietnamese student living in HCMC came here to work with me.

To give the two students that had to transport a desktop computer to school every day better conditions for developing software we decided to invest in two laptops. This was financed over the HISP Vietnam budget, and improved both the production and motivation of the students. The students were employed by HISP at the time, and the computers were owned by the project.

9.6 Capacity building

In the following section I will discuss efforts in regard to knowledge and capacity building in the Vietnamese student group, as well as issues limiting these efforts.

9.6.1 Student behaviour

When I entered the working room at the partner university for the first time I met seven extremely polite and friendly students. They bid me welcome and asked me whether they could help me in any way. They brought me drinks and showed me around at the university. They had even reserved a special seat for me in the room.

During my lectures the students listened carefully and answered my questions eagerly. They informed me if my content already was known to them, and asked me questions when something new was presented. My first lecture focused on basic concepts in DHIS 2 development like how Subversion is being used. It turned out that they were already familiar with these subjects. Later I talked about Webwork and Velocity and went through a web application made for demonstration purposes. My first impression was that the students were able to comprehend this information.

Later I distributed tasks to the students, who were sitting in pairs on each computer. The first group was going to develop a user interface for dealing with data elements in the Data Dictionary module. The next group was intended to develop a solution for synchronization of data elements between organisation units by using some kind of web-service functionality. The last group was responsible for exploring existing health standards in Vietnam. These

standards would later be used for creating sensible data elements and enable data integration with other computerised health information systems in Vietnam following the same standards.

After I had delegated the various tasks I was surprised to notice that the students did not start working. They were literally just sitting and doing nothing, even if I had provided them with background information and a well-defined task. After some time I carefully asked why they had not started working. They replied that they did not know where to begin. I decided to help each group to get started. I developed a user interface for data elements, and delegated the responsible students to develop a similar GUI for data element groups. This way they could modify my code instead of writing it from scratch. I introduced the synchronization group to Axis 2, which is an open-source framework for building web-services from Apache. To the standardisation group I suggested they could communicate with the IT manager at our partner health centre.

After the students had received some start-up assistance they started working enthusiastically. A few days later the GUI group had completed the data element group interface and the standardization group had obtained some information. An intuitive continuation for the GUI group would be to start working on the indicator GUI. For the standardization group it would have been natural to make a well-arranged list out of the obtained information. Instead they started listening to music and telling jokes to each other. After some time I asked why they did not continue their work. The answer was once again that they did not know what to do next, and I was forced to assign them new tasks. These incidents continued to happen every time the students did not have a specific task to do.

Apparently some of the Vietnamese students were a bit shy and reluctant when it came to writing messages to the project developer mailing list. They often send e-mails directly to Norwegian developers when having technical questions; not willing to expose their problems to the developer community.

9.6.2 Possible negative influence by the education system

Two facts regarding the education system were stated in the background chapter:

- The Vietnamese education system suffers from a basic lack of resources like teachers and teaching material. One reason for this is the tuition fee, which is generally low in order to make education available for the majority of the population.
- The education scheme follows established standards especially provided by Soviet systems.

These matters have some unfavourable consequences:

- The lack of resources entails that the educational institutions can not afford to prioritise qualifications and quality of the instruction. The salary of the teachers is low and they are given sparsely with time for conducting research. Instead focus is mainly on graduating as many students as possible.
- A traditional educational scheme based on students passively receiving information from their teacher is dominating. Teamwork and practical tasks are rarely included in

the curriculum. This gives the students poor conditions for building up abilities in individual problem solving, reflection and independent learning.

9.6.3 Lectures

During my stay I held a total of three lectures for the HISP students at the partner university. The first lecture was focusing on basic elements in DHIS 2 development. I talked about the structure of the central code repository and frequently used commands in Subversion. I went through a sample web application made by another student to illustrate how Webwork and Velocity are configured and being used. The second lecture focused on how Jira and Confluence are being used in the project. This was new material to the students, but they seemed to be taking it in. The third lecture was about Maven and frequently used commands, which the students already were familiar with. The students generally gave me good feedback on the lectures. They asked me questions when they were faced with new information and noticed me when they already were familiar with the content.

9.6.4 Workshop arrangements

Based on discussions between the HISP coordinators in Vietnam and Oslo and me, it was decided to arrange a ten-day DHIS workshop at the end of December 2005. The intention of this workshop would be to present the HISP project, demonstrate the functionality of DHIS 1.4, the Java report module, and the HMIS system. Another important subject would be setup of Vietnamese language and Vietnamese reports in DHIS 1.4. The participants were supposed to be the IT manager from the Planning and Financial Department of the MoH, a developer from MoH, the HISP employee in Hue, the vice director and the IT worker at the partner health centre, the doctor at the partner university, the HISP coordinator in Vietnam, the students from the partner university and me. The IT manager from MoH was intended to find a developer in Hanoi who were supposed to be trained in both DHIS 1.4 and DHIS 2. The chosen person later withdrew from the project before she had started working.

Shortly after sending out the invitations, the IT manager from MoH called and expressed his displeasure of being given status as a participant at the workshop, and that he would prefer to have status as a VIP guest. This reaction came in spite of the invitation not being focused on the role of participants, simply on who might have an interest in joining the different sessions. Additionally MoH already had agreed to come to HCMC to learn more about DHIS and work with the HISP team.

Originally the workshop was intended to be hosted at the partner university. The doctor later informed us that this was not possible because of the previously mentioned “open source profile” of the university. The HISP coordinator in Vietnam later arranged premises at the UTC for health care for professionals centre where he worked.

The HISP coordinator in Vietnam and I met to adjust the workshop proposal from the HISP coordinator in Oslo. We considered ten days to be too long to demand the IT engineer from MoU to stay. Additionally we wanted to put focus on convincing him about the strength and usability of DHIS 1.4, and not on informing him about the future plans for development of DHIS 2, which still was on the prototype stage. Based on this, we decided to split up the program in two. The first part would focus on DHIS 1.4, demonstrations and discussions

regarding the collaboration between MoH and HISP and regarding the implementation plans. We agreed to postpone the second part of the workshop. This part would focus on DHIS 2, development issues and on strengthening the HISP team in Vietnam.

The HISP coordinator in Oslo agreed to separate the workshop into a DHIS 1.4 and a DHIS 2 part. He emphasized that at the time the IT worker at the partner health centre, the HISP employee in Hue and me were the key persons with a view to achieving a stable version of DHIS 1.4, and that the challenge was to bring these people together without involving the partner university. He suggested that the IT worker and I went to Hue to work together with the HISP employee there. This would give the busy IT worker time to focus merely on DHIS.

The IT worker did not see the necessity of travelling to Hue. His opinion was that instructions from the HISP employee in Hue could be communicated over e-mail, and that he could not stay away from his job in HCMC for a long period of time. The end of matter was that the HISP employee in Hue was invited for a one-week stay in HCMC at the end of December to work together with the IT worker and me at the university health training centre.

9.6.5 Social efforts

During my stay I emphasized the social aspect of team building, as I considered human relationships between me and the students in the group and between the students as important in order to achieve a well-working development team. The students already knew each other quite well as they had been working together for six months. One of the students lived in HCMC and travelled to the university by motorbike. During my stay he came to my hotel and took the bus with me to the university. At two occasions he invited me to his house to have dinner and to meet his family. Occasionally we went out to a restaurant to have dinner or to a bar to have a beer. We established a good friendship during my stay, and we still keep in touch.

The students in the student group initiated day-trips to famous sights around HCMC and invited me to their homes. I sometimes invited them to have dinner at restaurants in HCMC. At my birthday they threw me a party and gave me presents. Altogether they were very nice to me and we had a good relationship.

9.7 University collaboration

In the following paragraph I will describe the collaboration with the partner university in HCMC. I will discuss disagreements on project direction, local contributions to DHIS 2 and major events that happened related to the collaboration.

9.7.1 Disagreements on project direction

The head of faculty at the partner university was not fully satisfied with the current direction of the DHIS project. He had a few concerns regarding the design of the DHIS 2 system. Firstly, he felt that the design was too much based on the data element class (ref. 6.4 for design overview). The reports being used in the HCMC health province implied defining one data element with several sub-elements, where the sum of the values of the sub-elements

should be equal to the value of the parent element. He meant that the current design made it unnecessary complicated to achieve this report design.

Secondly, the value property of the data value class is of type string. The head of faculty claimed this conflicted with object oriented design principles, as this property mostly contained a numeric value. He suggested making an abstract data value class and implementations for text and various types of numeric values.

Thirdly, he suggested utilizing the *composite design pattern* for representing the organization units. This was considered a common practise at the partner university for representing tree structures.

According to the implementation plan, an extended DHIS 1.4 based system would be installed in all facilities in HCMC province. This system would be replaced by DHIS 2 when it was ready for release. The facilities made use of two specific reports which had to be supported by the systems.

The head of faculty argued that DHIS 1.4 is a complex system with extensive functionality. Implementing it would require a great effort with regards to training and follow-up, and would possibly be too complicated to use for health workers with poor experience with computers and information systems. Additionally, this effort would be wasted if the system was to be replaced by DHIS 2 after short time, and a new round of training would have to be initiated.

Based on this argumentation he suggested to make a DHIS 2 prototype which could be used until the DHIS 2 release version was completed. He argued that the core was still under development and there was no outlook for the system to be ready for release for several months. E.g. the design of the data set concept was currently under major reconstruction, and the report functionality was believed to rely heavily on this. The prototype would only consist of static input forms and functionality for persistence and reports. According to the head of faculty this would cover the requirements in HCMC.

The HISP coordinator in Oslo refused this suggestion. He stated that DHIS 1.4 would be used as planned, and that it would not be reasonable to input data in a system without support for indicators, validation and aggregation of data. The head of faculty answered that this was not necessary in order to support the simple functionality required by the HCMC health department, but that he would comply with the decision. Still, he would like to continue with his DHIS 2 prototype as a research project within object oriented design and Java web frameworks. This entailed that the students would spend most of their time working with the research project and not on the main DHIS 2 version.

9.7.2 Local contributions to DHIS 2

The head of faculty and the students at the partner university made considerable contributions to the development of DHIS 2 even before some of them were employed by HISP.

The head of faculty had several thoughts regarding the design used in DHIS 2 (ref. 9.7.1). Even if not all of them were accepted and implemented, they acted as constructive criticism and resulted in the developers to reconsider the current design.

Developing a report module to support the needs from HCMC health service was given high priority during the two last months of my stay (ref. 7.2.4). JasperReport (ref. 6.1.5) and iReport (ref. 6.1.7) had been selected as frameworks for this module, which eventually was named *DHIS report tool* (ref. 8.2). When I arrived in HCMC I had no knowledge regarding these software libraries. I soon learned that one of the students in the student group had usable experience with the frameworks, and we agreed to work together in order to develop the report module.

The student introduced me to iReport by making a simple example design which connected directly to a temporary database. He went through it and taught me how to use the basic functionality in iReport. He later continued by making a similar simple example on how to programmatically use JasperReport, and how to create a report based on the previously made design. These sessions were very useful and spared me the burden of learning a completely new framework from scratch. The student and I collaborated well through the whole development process, and succeeded in making a sensible division of labour.

XML generation and parsing has a central function in dhis-report-tool and several other DHIS 2 modules. This has previously been solved in different ways in the various modules. It has required a great deal of code and has sometimes not been in compliance with best practises. The student working with me had knowledge about and introduced an open source library called xStream (ref. 6.1.9). This library serializes Java objects to XML and back again, and is powerful and easy to use. This turned out to be a great improvement for both the report tool module and other DHIS 2 modules, as it entailed a common way of handling XML and large blocks of code to be replaced by a few lines.

9.7.3 Resignation from the head of faculty

Around Christmas 2005 the head of faculty at the partner university told me that he had decided to leave the partner university and start working at a private university in the city centre. The key arguments for his decision were that the educational system at the partner university and other public universities were mainly focused on graduating as many students as possible, and not on qualifications and quality of the form of instruction. The small tuition fees charged implies poor salaries for the teachers and requires them to spend almost all of their working time lecturing. It also implies that the teachers have limited resources for maintenance of facilities and for teaching materials (ref. 9.6.2). Additionally the head of faculty expressed that:

“The Vietnamese educational system doesn’t teach the students to work independently. The system is based on giving the students information which they passively receive without reflecting on it.”

Head of faculty at the partner university

The head of faculty wanted a position where he could have more influence. The university he later would work for charged, in a Vietnamese context, a relatively high tuition fee. This made the university capable of offering the teachers high quality teaching material like books, computers and facilities, more time for the teachers to do research and higher salary. This naturally entailed higher quality of the teaching form. The head of faculty emphasised the

importance of creating an educational system which encouraged the students to reflect on what they were learning and to work independently:

“Only by urging the students to work independently we can improve the level of competence and enable Vietnamese IT workers to compete with IT workers from other Asian countries.”

Head of faculty at the partner university

He had a bad conscience for leaving the HISP project, being the initiator on the Vietnamese side of the cooperation. He had considered taking the project to his new university, but came to that it was a bit too early as he first needed to establish himself. On the other hand he was very eager to uphold the cooperation between the partner university and University of Oslo, and promised to find a suitable person to undertake his role.

9.7.4 Collaboration reasons for the partner university

In the following section I will describe two circumstances that were likely to encourage the partner university to continue the collaboration with UiO.

Firstly, in general Vietnam did not begin to emerge from international isolation until the end of its Cambodian occupation in 1989 (ref. 5.1.1). This has inevitable entailed a low degree of foreign relationships for the Vietnamese information technology sector. The Vietnamese government body considers foreign interaction as crucial in order to reach their national ICT goals and targets (ref. 5.4). This attitude is reflected in the educational system and hence at the partner university.

“We consider co-operation with foreign universities as important in order to raise the technical level of our students and prepare them for working in an international setting.”

Head of the IT faculty at the partner university

In other words, the partner university considered it important to give their students the possibility to improve their English skills and their ability to work in a global development team. The HISP project turned out to be favourable as it provided these opportunities.

Secondly, the partner university maintained an open source profile. This entailed that the curriculum consisted of subjects in close relation with free and open source technologies. Programming was only taught in Java and open source frameworks. Co-operation with a dedicated open source project like DHIS 2 was favourable in order to stand out with an image as an “open source university”. Likewise would the DHIS 2 course which the partner university tried to adopt from UiO fit perfectly into their curriculum and strengthen their range of subjects.

9.8 Communication problems

In the following paragraph I will describe various sorts of communication problems that emerged and possible causes for them.

9.8.1 Misconceptions of the situation in Vietnam

The project leaders in Oslo had an incorrect apprehension of the situation in Vietnam prior to my arrival. I was held out expectations of a situation where:

- The student group at the partner university had started working on the Data Dictionary module and a Ward Patient module.
- The partner university had an acceptable IT infrastructure well-suited for global open source development.

After meeting with the students and the partner university for the first time I quickly learned that this was far from the truth. The situation looked like this:

- The students had not started working with the Data Dictionary module. They did not know where to start and what the requirements were, and were waiting for me to get them started. The Ward Patient module had to be put off, and has not been realized since. Considerable training was required before the students were capable of starting the development process.
- The infrastructure at the partner university had several flaws that hampered global development and communication (ref. 9.5.1).

These misconceptions forced me to change my plans and required me to quickly learn new technologies and find solutions to practical and infrastructural problems.

9.8.2 Misunderstandings regarding project direction

The head of faculty at the partner university had several objections against the design of the current DHIS 2 system, and believed that implementing DHIS 1.4 in the HCMC health service would imply too high complexity and waste of training when it later would be replaced by DHIS 2 (ref. 9.7.1). Due to this apprehension he decided to start his own branch of DHIS 2, specially designed for the HCMC health service. The DHIS 2 coordinators in Oslo believed that this would act as a research project for the students at the partner university. After several attempts the coordinators in Oslo and I gave up persuading him to work on the trunk version of DHIS 2. Additionally, the branch version included report functionality that supported the specific reports required by the HCMC health department. Supporting this would buy us some more time in order to produce more generic report functionality.

The head of faculty on the other hand wanted his system to be implemented in HCMC, and informed the DHIS 2 coordinator in Vietnam of his decision. The last-mentioned person believed that this was cleared with the coordinators in Oslo, even if it was not. At the time I was not aware of this fact. This way this misunderstanding was able to prevail for several weeks. The coordinators in Oslo reacted with severe displeasure after I had discovered the misconception and informed them. The head of faculty was informed that he was not in charge of the implementation in HCMC and that the memorandum of understanding between the Vietnamese Ministry of Health and HISP stated that the extended version of DHIS 1.4 would be used. The head of faculty at the partner university later agreed to continue his branch version as a research project and not interfere with the implementation. One problem

was still that the report functionality in the branch version was based on the core of the very same system, and not on the DHIS 1.4 datamart database as the Oslo coordinators had believed. This meant that the previously mentioned report functionality was useless for the HCMC implementation.

9.8.3 Possible causes for the communication problems

During my stay I discovered a few concerns that may have contributed to the mentioned communication problems.

Geographical distance

The distance between Oslo and Vietnam is 9312 kilometres and requires an effective flight journey of approximately 17 hours. Flight tickets can be obtained at a cost of about 1000 USD. These facts imply that making journeys to the partner city and university is both time-consuming and expensive. Instead one has to rely on internet based communication tools. The project coordinators in Oslo are making journeys to Vietnam approximately every sixth month. There have almost continuously been one or more Norwegian master students present in Vietnam for the last two years.

Temporal distance

Vietnam is located at GMT +7 hours. As Norway is located at GMT +1, GMT +2 during the period of daylight saving time, this implies a temporal distance of five or six hours. This required the Norwegian developers to get up and schedule meetings early in the morning in order to access the Vietnamese developers before they went home from school or work. This was sometimes constraining the communication as many of the Norwegian developers have lectures or other jobs to maintain during the morning.

Another issue was the Vietnamese holiday schedule. The Vietnamese celebrate the annual *Tet* holiday from the beginning of January until February. This was hampering the work of the Norwegian student who replaced me in Vietnam, as the students went home to their domiciles and took a break from working. Also, all universities and health offices were closed during the holiday.

Lingual issues

The English language skills in Vietnam are varying, and in some situations able to create confusion and misunderstandings. One example is a mailing list discussion regarding the future direction of the implementation in HCMC, where the Vietnamese employee working for OutSoft came up with several requests. The project coordinator in Vietnam felt that he was overrun by this initiative and that the student was interfering with his work. He even threatened by quitting his position if the student kept on giving him instructions. The student later excused himself and claimed that his initiative was intended as suggestion and not as a demand, and that he had problems with expressing himself clearly in written English.

Lack of reporting

The project coordinators in Oslo claimed that the coordinator in Vietnam and the HISP contact person in HCMC health service rarely sent them any reports, and that this made it hard for them to get an impression of the status. On the other hand, the Vietnamese personnel claimed that reports were provided as agreed.

Unequal distribution of knowledge

The HISP coordinator in Vietnam is a medical doctor and has a wide expertise regarding the health sector. On the other hand, he has no technical background related to information technology. On the contrary, the HISP coordinators in Oslo have extensive knowledge regarding ICT and information systems, yet minor medical experience. This unequal distribution of knowledge impacted the communication between Oslo and HCMC, which is illustrated by the misconception of project direction previously mentioned.

9.9 Employment of the Vietnamese students

In the following section I will describe the process that led to the employment of the students from the DHIS group at the partner university.

9.9.1 Background

The process of employing the Vietnamese students offered a few challenges. The first challenge was to find a way to transfer money for salary to the Vietnamese students from the project's bank account in Norway. One way of accomplishing this would be to establish an organisation or project in Vietnam that could receive funding from HISP. At the time the funding was transferred to the HISP coordinator in Vietnam's personal account. This was obviously not an ideal solution.

The first alternative would be to establish an official organisation for HISP in Vietnam. Establishing such organisations in Vietnam is strictly regulated by the government. An application has to be considered by a large bureaucracy which may be a very time-consuming process, and not all applications are accepted. Based on this our wish was to let the partner university start a non-profit project within the university. This project would then open a bank account and let the HISP coordinator in Vietnam possess full control over it. HISP could then transfer the salary budget to this account, and the final payment could be done by the coordinator in Vietnam.

The second challenge was the delicate situation of employing only a few of the students in a student group where everybody worked together and used DHIS 2 as a basis for research and learning.

9.9.2 Meeting with the principal at the partner university

Later the HISP project leader and I met with the principal and the head of faculty at the partner university. After explaining the situation the principal had no objections against us

employing some of the students at the university. Nor had he any objections against letting the university become responsible for a HISP project.

The head of faculty was sceptical when it came to employing some of the students in his student group. His opinion was that having a student employed in a project working together with regular students in the same group would be unfair with regards to grades and follow-up. An unpleasant situation could emerge if one of the students was supposed to get special treatment. It neither would be satisfactory to have a person working all by himself.

9.9.3 First meeting with the vice dean at the partner university

After the head of faculty resignation episode (ref 9.7.3) I met with the vice dean, the head of the IT faculty and a doctor at the partner university to discuss whether further development would be a good idea and the eventual terms for further collaboration. The meeting resulted in a proposal with several obligations for both parts:

- The Norwegian developer going to Vietnam to replace me in January, together with the students in the HISP group, would give a few instructors an introduction to the project and training in the frameworks being used. They would also teach the instructors how to set up at server equivalent to the HISP server in Oslo. The partner university was committed to distributing the knowledge to other instructors and to the students.
- The University of Oslo would be responsible for giving a few yearly “seminars” regarding the development of the project.
- The partner university would be responsible for staying updated on the project and the technology being used.
- The partner university was committed to developing DHIS 2 modules and components on request by the HISP project leader.

According to the head of faculty the person who was intended to be responsible for the HISP project at the partner university was highly competent; even if his particular research area was network technology he had good knowledge about information systems.

We also discussed the possible employment of one or more students from the partner university to work in the HISP project. The head of faculty recommended us to hire three of the students. He argued that this was favourable since it would maintain the social fellowship and give the students better conditions for prosperity and succeeding in the work. He recommended three of his students as being the most skilful and independent-working. The students would finish their three-year education in January 2006. Due to inconvenient regulations at the university they had to wait until September before they could complete their education with a fourth year. Employing these students for nine months would be a good situation for all parts. It entailed continuity for HISP since the student’s knowledge would be preserved within the project. It would be flexible for the students since getting a nine-month IT job is quite uncommon. It would also be a job they could start in without needing to gain knowledge about completely new technologies.

The head of faculty informed me that a regular salary for a person with corresponding qualifications in HCMC would be USD 200 per month, which usually was raised to USD 230 after six months. He also told me that the partner university would place working environments for the three students at disposal.

9.9.4 Second meeting with the vice dean at the partner university

The second meeting with the vice dean took place a week after the first. The HISP coordinator in Vietnam and I wanted to finalize the discussions regarding the HISP project at the university, the employment of the students and the terms for further collaboration between HISP and the partner university; especially about the schedule for the three employed students after they would continue their education in September.

The vice dean had pointed out a lecturer to be responsible for the accomplishment of the HISP project at the university. The lecturer was reluctant about administering the HISP budget. He accepted it after we informed him that the headmaster had approved it. The lecturer informed us that the university would claim ten percent of every transaction made through this account. According to him this was normal procedure for money transfers in Vietnam. This was later negotiated to five percent.

The lecturer wanted our opinion about the schedule for the students. He was willing to let us influence this and let the students continue working with DHIS even after September. The lecturer was very eager to start a HISP course at the partner university like the one being held at UiO. To accomplish this he wanted the Norwegian developer who was replacing me to train the staff at NLU as well as their students. He suggested that he could hold three lectures a week for six weeks.

Our opinion was that this could be positive for maintaining the relationship with the partner university, and that it would have the potential to contribute to the DHIS 2 system on a long-term basis. The Norwegian developer would stay in Vietnam for three months, which made it achievable to give the necessary training to the staff at the partner university. We also emphasized the value of having a global network in a research context. Still this would not benefit the development on a short-term basis. As we believed this would tie up the Norwegian developer too much, we offered the lecturer a total of three lectures.

The lecturer objected that the partner university focused on object-oriented design, and that the DHIS 2 were beyond the analysis and design phase. He first wanted to participate in a total re-design of the system. We refused and promised him that he could bring up design issues and discussions with the core developers. If the changes were considered to improve the system, it would be implemented. He later accepted this.

The proposed commitments regarding collaboration between the partner university and University of Oslo from the previous meeting were approved. We also approved to employ three of the students. The salary was negotiated to USD 170 per month with a possible raise to USD 200 after six months.

9.10 The development team in action

The students started their jobs in HISP in the beginning of May 2006. Just prior to this the partner health centre had moved into new office premises, and HISP had made an agreement with the health centre which provided the HISP employees with working environments. At that time the DHIS 2 software, which had been released in a light version in January, had passed through a period of testing and adjustment and was starting to take shape. The employee's three main responsibilities have been:

- Implement DHIS 2 first at some selected pilot districts and later start a full scale implementation covering the whole HCMC.
- Provide training for end-users at the various wards, hospitals and district offices. The training has been focused on data entry, report generation and export and import of data.
- Make contextual adjustments to DHIS 2. As the system was installed at the various locations and utilized by health workers and statisticians; a great deal of feedback and suggestions revealed shortcomings and possibilities for improvement. The members of the development team are in a favourable situation as they have good knowledge and insight in the system and are capable of making changes. In addition they have a close relation with the end-users. They know the context they are working with regards to language, health system and working routines and habits.

Even if these processes were initiated after my return from Vietnam, I have been able to follow the development by examining the HISP wiki and the mailing lists and through communication with the Vietnamese employees as well as the Norwegian students in Vietnam. The HISP employees have also reported regularly to the HISP coordinators in Oslo.

The implementation process has made good progress. As of September 2006, DHIS 2 was installed and users were trained at 30 district offices, wards and hospitals in HCMC. 27 of these had started reporting data electronically upwards in the hierarchy (ref. 7.4.4). In Hue, DHIS 2 is installed and users are trained in four districts. The user training has been fairly successful, but is constrained by a widespread lack of basic computer skills among health workers. Still enduring efforts from the development and support team has improved the situation considerably.

Training is carried out at the premises of the partner health centre in HCMC. Each organisation unit sends two persons to participate in the training and 15 units take part at each session. Each unit is invited to two training sessions. First, the users are given a background presentation of the HISP project and the DHIS 2 software. Second, they are taught how to install the system and how to use the basic functionality through demonstrations. The users are provided with a document and a video file which describes in detailed steps the process of logging on to the system, entering data, generating reports, and making export and import of data. Presentations equipment such as video projectors is utilized in order to allow everybody to follow the instruction. After the demonstrations, the users are given time to practise on their own with assistance from the support personnel. At the end of the day, the users are given an informal test to which they have to pass in order for their training to be approved. The training has proved to be efficient; even if the users tend to need several repetitions of demonstration.

The second training session is considered as a follow-up session where users can ask questions which have emerged from experiences with the system since the training began.

The users from hospitals are perceived as of maintaining a higher level of competence than users from wards; apparently because hospitals generally have better computers and conditions for working. The pair of users from each unit consists of one person being responsible for the DHIS 2 effort and one person with computer qualifications. The intention of putting together this composition is to improve their confidence and ability for working independently with the system after finishing training, as one person has the organisational power for including DHIS 2 in the daily work and the other has the technical capacity for carrying out the installation, distribution of knowledge and actual work.

“To a training session I invite two persons from each unit; one responsible for DHIS and one with knowledge of computers. This way we make them confident and able to work without our support.”

DHIS support worker in HCMC

The HISP support personnel do follow-up on the hospitals and wards by making phone calls each month. The units are also able to call the support personnel. If technical trouble or questions regarding use have emerged, one person from the team travels to the unit that made the enquiry in order to help out. Still, only seven out of 30 units needed help in order to install the system.

The general feedback regarding DHIS 2 has been surprisingly good. Most users express that they are pleased with the use of the system and that the user interface is intuitive and easy-to-use. The users in particular emphasise the possibility to display and verify the entered data through the report module as important.

The HISP employees have increased their development activity significantly after the first release of DHIS 2. Their efforts have not been considerable directed towards the global development of DHIS 2. Instead focus has been on solving local requirements and making adjustments in order to satisfy end users in the Vietnamese health sector. Still these efforts have to a certain degree been adopted in the global solution by the core developers and thus benefited the global network. Some efforts to develop global functionality, e.g. a user administration module, have been attempted. Even if this attempt resulted in a partially working service module, major effort from one of the core developers in terms of assistance and guidance in order to complete it turned out to be necessary.

Part 4 Discussion and Conclusion



The head of faculty, students from the partner university and me having a deserved lunch break

Chapters included in this part:

- 10 Discussion*
- 11 Conclusion*

This last part presents my analysis and conclusions. The discussion aims at answering my research objective and questions through applying theory to my empirical findings. The conclusion will summarise my research and make clear my contribution to the discourse of global software development and capacity building.

10 Discussion

In this chapter I will explore my research objectives and discuss the empirical findings in relation to the presented literature and concepts from chapter 2 and 4.

Research objective: *Explore how global software development and local capacity building can improve sustainability of information system implementations in developing countries.*

I will address my research objective by drawing on experiences from my Vietnamese case study, and explore whether local development teams are suitable mechanisms for achieving the conditions for sustainability maintained by Braa et al. (2004). I will also explore challenges and disadvantages of this approach.

Research question 1: *Explore challenges and solutions regarding ICT capacity building in developing countries through participation in global software development.*

This research questions will be addressed using my experiences from establishing a local development team in Vietnam and global software development within the DHIS 2 network more generally. I will use a framework for analysis of distributed development provided by Lings et al. (2006), and explore whether the DHIS 2 network is adhering to best practises for distributed development provided here. Additionally, I will present the lessons learned from my efforts for software development capacity building in Vietnam.

Research question 2: *Explore challenges and solutions regarding adaptation of information systems to local contexts while maintaining global requirements.*

This research question will be discussed using my experiences from global software development in the DHIS 2 network and the development of a report module in Vietnam more specifically. I will base my investigation on the theories presented by Rolland and Monteiro (2002), and contribute to this discussion by analysing the mentioned adaptation process and explore how changes and extensions to a system can be designed in order to curb local-global tensions and benefit the global network.

The following sections will be presented:

- 10.1 - ICT capacity building in developing countries through participation in global software development
- 10.2 - Adaptation of information systems to local contexts while maintaining global requirements
- 10.3 - Local implementation and development teams as a means for sustainability in information systems implementations

10.1 ICT capacity building in developing countries through participation in global software development

In this paragraph I will address my first research question.

10.1.1 Challenges and solutions regarding global software development

I will use the framework for analysis of global software development provided by Lings et al. (2006) presented in the literature review. This framework is basically intended for traditional distributed development projects. My goal is to validate the DHIS 2 project against these strategies and principles, and explore the challenges that emerge in a context where the development is distributed across developing as well as developed countries.

The DHIS 2 project has resemblances with both OSS projects and traditional distributed development projects. Features present in the DHIS 2 project like developing under an open source license, publicly available source code archives, open communication, implicit coordination mechanisms, and the project being open for anyone to participate are classic characteristics of an OSS project. The project has likewise signs of commercial software development, such as detailed requirement specifications, plans for development, road maps, and commitment to demanding users with deadlines. The HISP project also hires development teams for outsourcing parts of the development. Maybe the most notable feature of the project distinguishing it from typical OSS projects is that it does not depend on volunteer participation. HISP will always as long as funding exists maintain a group of developers working on the system. The DHIS 2 could thus best be characterised as a hybrid project; a project with concessions to principles for both open source and commercial software projects.

Have a Clear Distribution Rationale

The conditions for the Norwegian-Vietnamese collaboration in HISP are not ideal with regards to the rationale for distribution. The temporal distance is relatively large with a time zone difference of five to six hours which few overlapping hours (ref. 9.8.3). This was sometimes hampering the communication as many of the Norwegian developers have other jobs or lectures during the overlapping hours. Still, this had a positive effect in relation to *follow-the-sun* work. Gradually a working routine emerged where the Vietnamese students dispatched e-mails to the Norwegian developers at the end of their day, which corresponds to early morning in Norway. The Norwegian developers would then have the whole day to respond, and in most cases the Vietnamese students would have the answer to their questions ready when they returned to work the following day.

The Vietnamese student's English skills were to some extent hampering the communication within the project. The Vietnamese have a peculiar pronunciation of English which relates to phonetic rules in their own language. Also, the Vietnamese students were a bit shy and reluctant regarding writing messages to the project developer mailing list. Sometimes they would send e-mails with questions directly to another developer in order to get help for technical problems, and it became apparent that they sometimes did not ask at all. This was eliminating one main advantage of the mailing list, namely that everybody could share

solutions for commons problems. It was also decelerating the learning progress for the Vietnamese students.

The DHIS 2 system itself is relatively well suitable for distributed development. DHIS 2 is a modularized system which is designed with a core module enclosed by several modules with various purposes and functionality (ref. 6.3). The plan for distributing the development of the Data Dictionary module to the Vietnamese student team was favourable for several reasons. First, the module had a stable and well-defined requirement specification. Second, the module was clearly terminated and thus decomposable into a discrete task. Third, the module could interact with an existing core module interface for data persistence and retrieval.

Clarify All Understandings

Two months previous to my arrival in Vietnam the HISP project leaders in Oslo had communicated with the leader of the student group at the partner university in Vietnam regarding the development of the Data Dictionary module. The DHIS 2 project uses Confluence, which is an enterprise wiki (ref. 6.2.3), as the backbone for communication. The module's requirement specification and background information had been agreed and documented here, and the commitments were seemingly understood. During my first days together with the student group in Vietnam I learned that even if the students had comprehended the task, they had not been able to start working. Even if they had a reasonable well understanding of the tools and frameworks being used in the development, they had not found an approach for the actual development (ref. 9.6.1).

The incident where the head of faculty at the partner university initiated a branch version of DHIS 2 due to disagreements regarding the implementation in HCMC (ref. 9.7.1) is clearly a situation that could have been avoided through formal agreements. When the head of faculty eventually informed the HISP coordinators about his decision, HISP was not in position to claim any entitlements regarding the direction of the development. This situation is clearly emphasising the findings of Bass and Paulish (2004) who state that “in the absence of clear direction, local cultural and personal biases are going to influence decisions. The resulting choices may not be in line with the overall goals of the project”. Written commitments could have ensured that the partner university's development efforts were following the mainstream development process of DHIS 2.

Leverage Modularity

The importance of a well-partitioned architecture is stressed by Bass and Paulish (2004), who claim that “in order to facilitate work break down across multiple sites, the architecture needed to reflect the organizational structure of the project”. The highly modularized design of DHIS 2 fits seemingly well with this statement. The core module is developed by the core development team consisting of Norwegian master students located in Oslo, and is responsible for data persistence and business logic. The system is extended by several modules which provide functionality built upon the core module (ref. 6.3). The modules are mainly well-defined components with understood dependencies to the core module, which itself make them suitable for distributed development.

This model can relatively well be translated to the network of nodes involved in the development of DHIS 2. The centre of the development is located at UiO in Oslo. HISP has

several nodes taking part in the development located e.g. in India and Vietnam, which mainly has been delegated responsibility for development of separate modules.

Distributed component development brings, as stated by Battin et al. (2001), with it the issue of system integration and the need to avoid “big bang” integration activity within a project (ref. 2.4.2). The HISP strategy for code integration and collaboration implies that developers from all development nodes make frequent commits to the central code repository in order to facilitate coordination and code integration (ref. 6.2.1). This effort effectively prevents occurrences of such “big bang” integration.

Use Cultural Mediation

Liaisons between teams have been found to be a very effective strategy for overcoming socio-cultural tensions within a project. Many companies and organisations have personnel who frequently travel between the key stakeholder sites in order to “facilitate the cultural, linguistic, and organisational flow of communication and to bridge cultures, mediate conflicts, and resolve cultural miscommunications” (Carmel and Agarwal 2001). Both the HISP coordinators in Oslo and Norwegian master students are taking upon this role. The HISP coordinators are making annual journeys to Vietnam, but the frequency of these visits is constrained by the large geographical distance between Norway and Vietnam of approximately 8000 kilometres. Since the fall of 2005, there have almost continuously been Norwegian master students present in Vietnam.

Several incidents emphasise the need for this kind of activity: First, the situation where the head of faculty started his own branch version of the DHIS 2 for research purposes (ref. 9.7.1) even without communicating the decision with the HISP coordinators in Oslo. This decision affected the collaboration with the partner university considerably since it allocated the working power of the students to labour which not profited HISP and the development of the DHIS 2 directly in any way. The presence of a “mediator” made it possible to sort out the misunderstanding and find an acceptable solution to the problem. This would probably have been difficult to achieve for the HISP coordinators located in Oslo.

Second, monitoring project progress at a close distance turned out to be necessary in order to get a realistic apprehension. Previous to my arrival I was given the impression by the HISP coordinators in Oslo that the Vietnamese students had made progress in the development of the Data Dictionary module. After exploring the situation it became apparent that the students had been waiting for me to start them off. This kind of disparity between the conveyed impression and the real situation appeared to be hard to unveil without the physical presence of a liaison.

The Norwegian master students were demanded to have broad IT skills in order to deal with a variety of technologies and tasks. Unconventional problems which demanded creative ad-hoc solutions emerged continuously. One example of this was the initial strategy for the DHIS application suite which was intended to be a collocation of the HMIS application developed by the ministry of health, the DHIS 1.4 and a DHIS 2 report module (ref. 7.2.3). This solution would force the developers to create bridges for data transfer and communication between the various systems and develop a report module from scratch (ref. 7.2.3). This had a positive effect as it required the developers to be problem-solvers and entailed a high degree of learning.

Also, the Norwegian “mediators” were required to have skills beyond mere technical capabilities. Tactical skills were demanded for negotiations and discussions, e.g. in order to get an advantageous agreement with the partner university regarding collaboration (ref. 9.7) and employment of the students (ref. 9.9). Social skills were needed for team building and in order to create enthusiasm for the DHIS project among the Vietnamese students (ref. 9.6.5). Good learning skills were necessary in order to deal with the continuously emerging new technical frameworks, technologies and information systems (ref. 9.5.4).

Facilitate Human Communication

Face-to-face communication is still acknowledged to be the best in most situations, but is clearly not always practical (Lings et al. 2006). Hence, a number of communication strategies have been used to maintain elements of synchronous communication. For example, Ebert and DeNeve (2001) recommend provision of “sufficient communication means, such as videoconferencing or shared workspaces and global software libraries” as an approach for improving human communication within distributed projects. However, current technology often brings with it the inherent “challenge of delay due to inadequate asynchronous communication” (Damian and Zowghi 2002, p. 10).

Videoconferences or shared workspaces are not being used within the DHIS 2 project. The most widespread synchronous communication means being used is instant messaging, and to some degree VoIP (ref. 6.2). Instant messaging clients are in fact well suitable as facility for communication since most people are familiar with it, it can stay active for long periods of time; letting developers pop in with questions when needed, and support transfer of documents and images.

The need for human communication in order to maintain coordination within the DHIS 2 project are reduced by the usage of communication and coordination tools like code version control, issue tracking systems, wikis, and mailing lists (ref. 6.2). These tools have in common that they rely on access to a stable internet connection in order to function properly. The relatively poor infrastructure regarding internet connection and usable computers made the premises for communication and thus software development worse for the Vietnamese students. Creative initiatives, e.g. using internet cafés as workplaces and buying laptops to some of the students (ref. 9.5.4), turned out to be necessary to facilitate communication and get progress in the development process.

Encourage Temporary Collocation

Temporary collocation is utilized as a strategy for maintaining morale and motivation among team members, improving awareness of local working contexts and contributing to better communication with sources of requirements (ref. 2.4.2). The HISP workshop in South Africa in September 2006 acted as such temporary collocation. This workshop gave the students and developers working with the DHIS 1.4 and DHIS 2 the opportunity to communicate face to face with the core developers of the respectively systems, and inform about local requirements and suggestion for improvements (ref. 8.4). The various development teams got to present locally developed modules and receive feedback from the HISP senior developers and coordinators. This close collaboration entailed precise communication and short response time regarding development of new and desired functionality (ibid.).

Another aspect of the workshop not to be underestimated was the opportunity for the developers previously only known to each other by way of interaction through email to socialise. Social relations are likely to encourage and lower the barrier for communication, and improve motivation and morale because of the psychological aspect of team spirit.

Encompass Heterogeneity

According to Lings et al. (2006) heterogeneity in tools and terminology is likely to be unavoidable in a distributed project, and should be carefully planned for. Especially mentioned is the possibility for a tool not being marketed and supported in all locations. Also, the possibility of shipping a common set of tools to all sites may be constrained by licensing.

The DHIS 2 project is using exclusively open source development frameworks and communication tools. This strategy evades several problems regarding accessibility and licensing. All of the tools being used are listed on the HISP wiki, and are freely available for download on the internet. This entails that most HISP nodes are using the same framework for development, which entails obvious advantages for coordination. Still this homogeneity often implies need for extensive training of the members of the various development teams before they are capable of making valuable contributions to the system (Nordal 2006). Battin et al. (2001) report on the need to accommodate existing processes, to “let each team begin producing results immediately, using a process they were familiar with.” This goes well together with findings from the HISP development team in India where the training of DHIS 2 technologies were suffering from a lack of progress and letting the developers using the technology they already were familiar with turned out to be more fruitful (Nordal 2006).

10.1.2 Challenges and solutions regarding ICT capacity building

In the following paragraph I will analyse the conditions and challenges for software development capacity building in my case study. I will suggest solutions to the mentioned challenges and try to draw general conclusions.

Political issues

The Vietnamese IT industry has to some extent experienced isolation and lack of interaction with foreign companies during the communist regime (ref. 5.1.1), implying that the education system suffered from a lack of international influence and stimulus. This situation apparently entailed that the partner university was eager on maintaining the collaboration with HISP as they considered international co-operation as important for their further development (ref. 9.7.4).

Comprehension of the user domain

During the first implementation effort in Vietnam, HISP concluded an agreement with OutSoft, a large outsourcing company in HCMC (ref. 9.2). HISP's intention behind this agreement was to establish development competence among some of the interns at the company through training in DHIS 2 technologies, while they at the same time acted as support personnel for the ongoing DHIS 1.3 implementation process. The purpose of carrying out these two processes in parallel was to give the interns a comprehension of the user requirements and user domain within the health sector in HCMC as well as exercise in

requirements management. This plan failed because the interns stated that they were merely interested in development and Java technologies and not in implementation efforts, particularly not since the system currently being implemented was the MS Access based DHIS 1.3. This evident lack of interest in the user domain had a seemingly negative impact on the interns development performance, as none of them managed to produce a fully working module.

The partner university in HCMC was the entry point for the HISP effort initiated during the fall of 2005 for building an independent development team (ref. 9.2). The university had a genuine interest in open source software and global software development and maintained a profile as an “open source university” (ref. 9.7.4). This self-declared attitude towards open source software entailed both advantages and drawbacks for HISP. On the one hand, it entailed motivation for the university to maintain collaboration with HISP; which extensive use of open source frameworks and technologies fitted well with their profile and curriculum (ref. 9.7.4). On the other hand, the attitude implied that the partner university was unwilling to deal with the proprietary Microsoft Access based DHIS 1 versions. This reflected the same problem that occurred during the collaboration with OutSoft since HISP’s plan for the development team implied that the members would work partly as support personnel for the implemented DHIS version, which at the time was DHIS 1.4. The decision taken during the spring of 2006 to implement the DHIS 2 system in Vietnam made the partner university and the students willing to participate in the implementation process. Their experience and interaction with the users of the system, their requirements, and their working routines, has been an important factor for their ability to develop context-specific functionality and adapt the system to the local context. This will later be elaborated in section 10.3.1.

Comprehension of the software architecture and design

At the time HISP’s first collaborative effort in Vietnam was undertaken, the DHIS 2 was in a state where only the persistence layer and parts of the service layer were completed. There had not been developed any usable modules with user interfaces e.g. for data entry or maintenance of metadata. This had a few unfortunate consequences for the DHIS 2 development. Firstly, it was hard to get a complete apprehension of the system since there was no user functionality attached to the data model. This implied that explanations and demonstrations of the system for potential users and developers were hard to accomplish. Secondly, developing the first of such modules is a challenging task. Several aspects have to be considered and many issues regarding how to utilize e.g. the web presentation layer framework (ref. 6.1.4) and the application framework (ref. 6.1.3) have been sorted out in the process leading to the stable version of the system.

The release of the DHIS 2 light version contained six web modules. These modules acted as standards for web module development within the DHIS 2 project with regards to the previously mentioned frameworks and mark-up syntax. The increased development activity within the DHIS 2 community after the DHIS 2 light release indicates that using one or more complete modules as a basis make development easier and more feasible. The incidents with the failed efforts of developing such modules from the interns at OutSoft, the partner company during the first collaborative effort (ref. 9.2) in Vietnam, support this assertion.

Practical problem solving

The biggest challenge regarding teaching of the Vietnamese students at the partner university during the second collaborative effort turned out to be the student's attitude for learning. The students were disciplined, motivated and skilful; they spent approximately eight hours at school every day, worked hard with their assigned tasks, and had obtained a considerable base of knowledge for DHIS 2 development (ref. 9.6.3). On the other hand they suffered from a deficit of individual initiative and the ability for independent problem solving. In order to achieve progress they had to be given specific work tasks. Incidents from the first phase of my training and co-development with the students where the students started playing music and talking about everyday matters after finishing assignments (ref. 9.6.1), emphasise this assertion. The students' attitude was apparently partly a consequence of the education scheme of the Vietnamese educational system. This system is still inspired by Soviet standards; based to a large degree on the students passively receiving information and suffering from a lack of teamwork and practical problem solving, something which obviously entails poor conditions for development of abilities regarding reflection and independent learning (ref. 9.6.2).

The students at the partner university was employed by HISP in January 2006 (ref. 9.9), and their main responsibilities became implementing DHIS 2 in HCMC and Hue, provide training for end-users at health offices, and develop context sensitive functionality and adjustments to the system (ref. 9.10). This work exposed them to direct feedback and requirements from the users of the system. An illustrating example is the development of the report module, as described in chapter 8. The various health districts in HCMC and Hue required DHIS 2 to be able to produce exact replications of their existing paper based reports (ref. 8.3.3), which lead to a huge demand for extended functionality in the report module and assortment of report designs. These requirements were often urgent, and needed a quick solution if it was not to delay the progress of the implementation. Reports from the Norwegian master student present in Vietnam at the time and observations of the software configuration management mailing list (ref. 6.2.4) gave evidence of increased comprehension and development activity among the Vietnamese employees. This situation shows that dealing with a complete information system and specific requirements from users seemingly improved the ability for problem solving and independent learning among the employees.

Ownership and commitment

During HISP's first implementation effort in Vietnam, a main reason for the interns at OutSoft to refuse to participate in the implementation process was that the DHIS 1.3 system in use had merely been developed by the HISP senior developers in South Africa, and from there been exported to Vietnam. Because they had not been a part of the development in any way, they did not feel responsibility or ownership for the system or the process.

These circumstances stand out in contrast to the situation with DHIS 2 and the development team constituted by students from the partner university in HCMC. The students have undergone a comprehensive training schedule and made considerable contributions to the system. They have been a part of the development process, and been responsible for the adaptation of the system to the local context. This implies that they have a personal ownership and joint responsibility in the system, which entails increased motivation and desire for getting a working system into use.

10.1.3 Summary of software development capacity building

In this section I will summarize my findings regarding building of software development capacity.

- The Vietnamese IT sector's lack of interaction with foreign companies and universities influenced the partner university's interest for international collaboration in a positive direction.
- Combining software development with implementation support entailed comprehension of the user domain and training in requirements management. These skills are vital for the developers' ability for creating context-specific functionality and adapting systems to local contexts.
- The release of a functional DHIS 2 version entailed realistic environments for software development, which facilitated comprehension and demonstration of the system as well as development of new modules and extended functionality.
- The Vietnamese educational system apparently influenced the students' ability for individual learning in a negative direction. Exposing the students to requirements and feedback from users of a functional system forced practical, independent problem solving, which eventually entailed increased learning.
- Involving the implementation support team in the development process entailed personal ownership and joint responsibility in the system, and increased motivation for getting a working system into use.

10.1.4 Benefits from global software development in local capacity building

In this section I will account for how the global HISP software development community has benefited local ICT capacity building in Vietnam.

Realistic environments for software development

The DHIS 2 project has started to take shape and can be considered a full-blown global software development project. Even if the Vietnamese students at the partner university have gone through a broad syllabus and have reasonably good theoretical background for software development, they have no experience with working in a realistic development project. As previously demonstrated; participation in a realistic development project has entailed several benefits for the students related to learning. Firstly, practical problem solving has increased learning. Secondly, carrying out implementation duties has entailed comprehension of the user domain and training in requirements management. Thirdly, examination of complete and working modules has facilitated the development process.

Human resources and sharing of best practises

Through their participation in the global DHIS 2 project; the partner university and company in Vietnam have got access to a global network of skilled people, extensive training programmes, and best-practises in software development and implementation through face to face meetings and online communication. Several Norwegian master students and project coordinators with skills in software development and expertise in information systems have

over a period of two years worked in Vietnam together with the Vietnamese partners. These master students have carried through lectures, training, and follow-up, and contributed significantly to the student's learning processes. Additionally, the Vietnamese students have been given the possibility to take advantage of information and communication sources in the project like the wiki (ref. 6.2.36.2), which contains information about and guidance for development. Also, through communication tools like the mailing lists (ref. 6.2.4) and the bug-tracking and project management application (ref. 6.2.2); the Norwegian master students have been able to continue the support and guidance of the Vietnamese students after returning home. Furthermore, in their local implementation efforts, the Vietnamese team has been able to draw on experiences and lessons learned from the ongoing implementation in India that have been documented and shared on the global mailing list.

10.2 Adaptation of information systems to local contexts while maintaining global requirements

In this paragraph I will address my second research question.

As stated by Rolland and Monteiro (2002); a considerable body of literature has demonstrated empirically as well as analytically that information systems need to be situated to the local context of use. For information systems that cover multiple contexts spread out globally it is impracticable to "fit" equally well (ref. 2.1.2). Rolland and Monteiro argue that the real issue is to analyse how global, never-perfect solutions are moulded, negotiated, and transformed over time into workable solutions. Through this analysis, the work and costs associated with the process of making solutions acquire universalism can be articulated and made explicit. Eventually, an evaluation of whether the distribution of these is reasonable can be made (Rolland and Monteiro 2002).

In my case study of the development and implementation of the report module; the mentioned process of moulding and adjustments to the Vietnamese context was carried out by the development team from the partner university and me through changes and extensions to the functionality. My contribution to this discussion is to analyse the mentioned adaptation process and investigate how the changes and extensions can be designed in order to curb local-global tensions and benefit the global network.

DHIS 2 is a global system used in several countries worldwide and is required to work in an equivalent number of contexts. The report tool is presumably the most *context-sensitive* module within DHIS 2; meaning that the functionality is closely attached to the conditions and situation it is working in. E.g. the data dictionary module (ref. 8.2) in DHIS 2 is less context-sensitive since the way metadata is defined and entered is likely to resemble across locations compared to the highly fluctuating requirements for report designs.

The report tool had several uniform requirements (ref. 8.3.3):

- *Simple report design:* The system needed to provide an easy-to-use interface for making basic reports based on report templates for health workers inexperienced with computers.
- *Reusability:* The report designs had to be suitable for reuse, e.g. it had to be possible to regenerate a monthly report for each month of the year.

- *Interoperability:* The system had to be applicable for both DHIS 1.4 and DHIS 2, since both systems lacked proper report functionality.
- *Charts:* The module had to be able to present charts embedded in the report designs.
- *Flexibility:* The system had to support flexible selection of parameters like data elements and organisation units in order to benefit from the advantages of a computerised health information system.

These requirements were provided by the HISP project leader and coordinators and were based on previous experiences from developing report modules in connection with DHIS 1.4. During the work with the report tool for DHIS 2; several local requirements emerged, both from Vietnam and India. The most influential were:

- *Special characters:* The module was forced to support rendering of the characters in the Vietnamese and Indian alphabet. These characters are not included in ASCII, which is the most commonly used character scheme in western countries.
- *Exact replications of existing reports:* The health department in HCMC required the module to be able to produce exact replications of the existing paper based reports.
- *Child organisation units:* Supporting several organisation units in a report was necessary since a report used by the partner health program in Hue contained data for all child organisation units of the main unit.
- *Several periods:* A report used in Kerala state, India, compared the values of the reporting month with the values of the corresponding month the previous year; hence the report tool needed to cater for several periods in one report.
- *Multiple pages:* Since some reports in Hue district spanned several pages; this had to be supported by the report module.

Rolland and Monteiro (2002) emphasise the negotiations around striking a balance between the need for information infrastructures to adapt to the various local contexts they are to operate across, while simultaneously coping with this complexity by leaning toward universal solutions. My assertion is that making extended functionality as *general* as possible curbs these tensions between the local and global and benefits the global network. In the following section I will elaborate on this by investigating the previously listed local requirements to the DHIS 2 report module.

Special characters

During the development of the report module it appeared that xStream (ref. 6.1.9) uses ASCII as default character encoding when writing to and reading from XML files (ref. 8.3.4). This is natural as ASCII is the most commonly used character encoding in western countries. This entailed a problem for the report module since Vietnamese character is not included here. ASCII encoding uses one byte for mapping characters to numbers in a set, which implies that the set can contain every letter in the Latin-based alphabets, in addition to a range of special characters.

There has been developed a number of character encoding schemes for the Vietnamese alphabet. Microsoft has implemented a codepage used in the Windows operating system called Windows-1258 used for representing Vietnamese text. Another Vietnamese character set is called VISCII (Vietnamese Standard Code for Information Interchange). India, despite maintaining 18 official languages, also has a national character encoding standard called ISCII (Indian Script Code for Information Interchange).

One solution to the problem with the rendering of the Vietnamese special characters would have been to develop a local branch of the module using the Vietnamese-specific character encoding. A disadvantage with this solution is obviously that this system would not be applicable for DHIS 2 installations in e.g. India. Instead, this solution should preferably be made as general as possible.

One means for achieving generality regarding character encoding is Unicode. Unicode is an industry standard designed to allow text and symbols from all of the writing systems of the world to be consistently represented and manipulated by computers (ref. 8.3.4). The most popular character encoding for Unicode is UTF-8, which is variable-length and able to represent any universal character in the Unicode standard.

Writing and reading of XML together with other functionality related to input from and output to file in the report module was eventually implemented using UTF-8. This way the module stayed unspecific regarding the Vietnamese context, and the character encoding did not constitute any obstacle for global usage of the module.

Exact replications of paper based reports

A highly emphasised requirement from the health department regarding the report module was the possibility to create exact reproductions of the existing paper based reports. This desire was apparently based on the symbolic value of these reports as they acted as confirmation of the labour undertaken by the health workers (ref. 8.3.4). This requirement is to some degree inconsistent with the incentives of maintaining a computerised health system, which is the capability to perform dynamic data analysis with aggregation and comparison in time and space. Still, supporting this requirement was necessary in order to satisfy the health department.

The local requirement for exact replications of reports from the health department in HCMC emerged to be in a foul conflict with the global requirement for flexibility in selection of report data. In order to cater for the first mentioned requirement I had developed a method for adding the elements needed in the report one by one as individual parameters, as described in 8.3.3. This method was suitable in terms of being able to position each report element at the desired location in the report. The feature of individual positioning of report elements implied that it was possible to design a report down to the details, and hence create exact replications of the currently used paper reports.

The disadvantage with this approach was that it constrained the possibility for including dynamic lists of data in the reports, and thus the ability to support the global requirement of general flexibility in selection of data from the HISP coordinators in Oslo. This request implied the need for including e.g. data values for all data elements in a data element group and data values for all organisation units in an organisation unit group for a given data element (ref. 8.3.3). The approach of adding single elements to the report was obviously not ideal for this type of functionality, as it would imply an unreasonable high number of report elements.

This considerable conflict between the need for detailed designs and dynamic schemes of report elements continued to produce challenges throughout the development process. Eventually it led to compromises and support for special cases like functionality for including

data for all children of the main organisation unit of the report. This will be elaborated in the following section.

Additionally, this conflict gave birth to the BIRT report module. BIRT is a reporting system (ref. 6.1.8) which is optimized for dynamic and flexible management of data in reports and a suitable framework for covering the mentioned global requirement. The *BIRT report viewer* module was developed by me during August 2006 (ref. 8.2), and the opportunities and possibilities provided by the BIRT report system is as of October 2006 still being explored.

This situation illuminates the tensions between global and local requirements which can emerge in a system that spans several contexts in multiple countries. It demonstrates that it is not always possible to find general solutions that will fit to all requirements, and that reasonable compromises sometimes have to be made. Additionally, this situation indicates that splitting up the functionality exposed to local-global tensions into separate modules in order to deal with different concerns can be a favourable strategy.

Child organisation units

A report used by the partner health in Hue province in Vietnam contained data values for every child organisation unit of the main organisation unit in the report (ref. 8.3.4). The process of manually designing this report implied a huge load of tedious work, as each report element had to be added manually to the report. In order to relieve the HISP employees in Vietnam from this job, we decided to make functionality for automatically generating and displaying this information.

A function for catering for this requirement was eventually implemented by the development team in Vietnam. After the user had selected a data element to include in the report, he was given the possibility to add report elements for every child of the main organisation unit of the report. This solution worked in terms of covering the demand from the Hue health department and relieving the Vietnamese employees from unnecessary workload. Still it was a kind of an *ad-hoc* solution as it did not allow for smooth rendering of different number of children in the report design. Additionally, the Vietnamese employees included this functionality in a separate branch of the system intended only for Hue province.

As this kind of functionality probably would be of interest to other districts, provinces and even countries where DHIS is being used, I decided to try to generalise this functionality. My first step was to create functionality for using several organisation units in the same report, not tied to the children of an organisation unit (ref. 8.3.4). This functionality was implemented as a separate report type in addition to the standard type (ref. Figure 14). With this report type, users could include random organisation units, e.g. in order to benchmark indicator values for a given period. The function for adding children of an organisation unit was included as well.

This situation demonstrates how making general solutions to local requirements can avoid the need for creating branches of the system for use in specific locations, as well as how it potentially can benefit the global network. Including the mentioned functionality in the global solution is favourable as it is likely that the requirements will emerge at other locations as the HISP network of nodes expands. This also illustrates how local specific requirements emerging from local implementation processes can lead to enhanced global functionality and use.

Several periods

The reports used in Kerala, India, contained data for several periods (ref. 8.3.4). At the time HISP was being implemented in this state, the report tool did not support this requirement. The result was that the local development team started developing a separate report module using JSP as framework for the presentation layer. This module support the request for two periods in a report by hard-coding it into the data model and the parameter input form. This way the module meets the requirements from the health department.

There are two main disadvantages with this approach. Firstly, by making the functionality static, i.e. bound to exactly two periods, the module will only be appropriate for reports using that number of periods. This entails that the module are of limited value to other HISP nodes. If this functionality had been made dynamic and general, it could have been integrated in the global report module and benefited other health district utilizing more than one period in their reports.

Secondly, the module does not take advantage of the qualities of the global report module. The module developed in Kerala is rendering the reports through plain JSP, which entails slow processing and a huge memory footprint. According to *best practises*; reporting functionality should be developed using some dedicated reporting library, e.g. the JasperReports (ref. 6.1.5) framework, which is used in the global report module, or the BIRT (ref. 6.1.8) reporting system, which entails more flexibility and more effective rendering of reports. Also, the Kerala report module does not allow for charts in the reports equivalent to the global report module.

On the other hand; this situation illustrates an important aspect of the theories of Rolland and Monteiro (2002), who “aim at articulating some of the work and costs associated with the process of making solutions acquire universalism”. The work for making the report module acquire universalism is carried out by developers through development of extended or added functionality. In the case of the Kerala development team; making a specific solution to the requirement specification from the local health department required far less work than creating a flexible and general solution. Hence, the work and costs in the process of making universal solutions has to be articulated and reasonably distributed, as stated by Rolland and Monteiro (2002).

Multiple pages

Some of the reports used in Hue province spanned several pages (ref. 8.3.4). Generating one report page at the time implied unnecessary workload for the development team, and functionality for generating the whole report at once was desirable (ibid.). Eventually this problem was solved by the Vietnamese development team, who implemented a clever solution for assembling the different pages into one. Since this was an exclusive requirement from Hue province at the time, they decided to add this functionality only to the previously mentioned branch of system intended for Hue.

Creating branches of a system is regarded as appropriate for experimenting and testing new functionality. On the other hand it entails more source code to maintain and potential integration issues when changes are introduced at a later stage. This implies that each time some new functionality would be developed for the global report module, this would have to

be integrated in the branch; a process which is not always appropriate and possible due to potential evolved differences in the system structure.

Also, as previously mentioned; maintaining this kind of general functionality only in local branches is not benefiting the global network. As the requirement for reports spanning several pages are almost guaranteed to emerge at other sites in the HISP network; this functionality would be favourable to include in the global solution.

Due to these reasons, I encouraged the developers in the Vietnamese team to incorporate this functionality into the global report module. This proposal was complied with and the work was accomplished during October 2006.

10.2.1 Summary of adaptation to local contexts while maintaining global requirements

In this section I will summarize my findings regarding adaptation of information systems to local contexts while maintaining global requirements and attempt to draw some conclusions of general validity.

- Making solutions to local requirements as general as possible allows for including the functionality in the global solution and avoiding maintenance of local branches, and hence curb local-global tensions.
- Developing general and flexible solutions to local requirements can benefit the global network if similar requirements are likely to emerge at other nodes.
- Developing general solutions implies a higher cost in terms of labour compared to local and specific solutions.
- In situations where requirements implies inconsistent functionality; splitting it into separate modules in order to deal with different concerns can be a favourable strategy.
- Maintaining branches with local and specific adaptations can potentially entail integration issues and fail to benefit from the global development effort.

10.3 Local implementation and development teams as a means for sustainability in information systems implementations

In this paragraph I will address my overall research objective.

The WHO Alma Ata declaration (ref. 2.3.2) worked out in 1978 describes a global vision of *health for all* through equitable access to basic health services, in which HISs were given a key role as a means for improving resource allocation. History has revealed that a high degree of the attempts of implementing HISs in developing countries has failed to persist over time. Braa et al. (2004) have identified two main themes of causes leading to these failures.

The first theme concerns the challenge to make an information system work over time in a local setting (ref. 2.2.3), and denote this as the problem of *sustainability*. Braa et al. list three vital conditions for improving sustainability in information systems implementations:

- Requirements gathering and contextual system adaptations
- Cultivation of local learning processes
- Establishment of persistent working routines

The second theme concerns the problem of how to make one working solution spread and adapt successfully to other sites (ref. 2.2.3), and is denoted as the challenge of *scalability*. As the concept of scalability in a health care context can be considered as a means for sustainability (ref. 2.2.3); Braa et al. look focus on two important conditions:

- Reproduction and translation of necessary learning processes
- Distribution and sharing of artefacts, technology and knowledge

In my further analysis I will account for how effective development teams can improve the mentioned conditions identified by Braa et al. for sustainability and scalability within IS implementations. Finally I will discuss disadvantages and implied costs related to this process. The main purpose of my stay in Vietnam was to contribute to the establishment of an independent, local software development team, and I will use these experiences as a basis for my analysis.

10.3.1 Requirements gathering and contextual system adaptations

The DHIS 2 project has its base at UiO in Norway, and the project coordinators and core system developers are located here. Until 2004, the system was developed solely from Oslo based on global requirements gathered from experiences and existing solutions in DHIS 1.4.

Previous HISP implementation and development efforts have maintained a view of information systems as social systems (ref. 2.1.1). This view calls for focus on social aspects of IS and emphasise the importance of user participation and the need for taking the context of the system into account (ibid.). User participation is seen as favourable since it can improve the knowledge upon which the system is built, enable people to develop realistic expectations, and reduce resistance to change.

The need for knowledge of local contexts and requirements emerged contemporary with the concrete plans for the DHIS 2 implementations in Vietnam and India in 2004. In order to achieve successful implementations in these countries, HISP acknowledged that the development of the system needed to be distributed from Oslo to the local sites. Local participation and contact with the users of the system were considered as vital for the process of shaping and adapting the system to the local context. The idea of trying to establish a local, self-sufficient development and implementation team in Vietnam grew out of these circumstances.

In January 2006 HISP managed to employ and establish a group of three Vietnamese students from the partner university (ref. 9.9). The team has since been responsible for making contextual changes to the DHIS 2 software and carrying out the implementation of the system in HCMC and Hue.

Maintaining such a local development and implementation team has turned out to be favourable for several reasons. Firstly, the team consists of Vietnamese inhabitants. This is advantageous compared to foreign researchers since they have better conditions for understanding the local contexts through language proficiency and cultural knowledge. A minority of the Vietnamese people has good lingual skills in English, and creating support material and perform training in Vietnamese is obviously a great advantage.

Additionally, external researchers in a southern context are acknowledged to be exposed to issues like being associated with bad experiences with foreign intervention, hostility, hiding of local information, feeling of obedience to the educated outsider, and power arrangements threatened by new changes (ref. 4.1.1). A team of domestic members has better possibilities for building trust and confidence among users, and thus better conditions for creating goodwill, reduce resistance to change and receive sincere and realistic feedback regarding the implemented system.

Secondly, the team has throughout the implementation process carried out training sessions with the users and travelled to the various districts offices, hospitals and wards in order to perform the system installation and setup when required (ref. 9.10). This kind of efforts provides them with the possibility of ensuring that the installation is working and has been properly done, and fix problems that might have occurred (ibid.). A main reason for the DHIS 1.3 implementation to fail was precisely HISP's lack of ability to supervise the technical aspect of the implementation and fix errors and bugs within a reasonable period of time (ref. 7.1.3). By maintaining a local support team able to quickly move out into the field when help and support are needed; incentive and motivation for using the system is improved among users.

Additionally, the training sessions and regular visits to hospitals and wards provide an excellent opportunity for user participation in terms of receiving direct feedback and suggestions for improvements. The ability of communicating directly with the users in their relevant context has proven to be of great value for requirements gathering (ref. 9.10). Several changes and requirements to e.g. the DHIS 2 report module has emerged as a consequence of user feedback received by the Vietnamese team (ref. 8.3.4).

Thirdly, the members of the team have been trained in the technologies and frameworks being used in the DHIS 2 project through training at the partner university and practical development of the system, and are capable of making changes to the system (ref. 9.6.3). This entails short response time between user feedback and corresponding development efforts, which potentially can increase motivation and participation among users as they observe that their opinion actually is influencing the system.

Also, using the same personnel for requirements gathering, implementation and development is favourable as it reduces the communication chain and hence the risk for misconceptions between users and developers regarding requirements. In the case of the DHIS 1.3 implementation; user feedback had to be received by the limited support personnel in Vietnam and translated into a user requirement. After that it had to be communicated to the senior developers located in Cape Town, South Africa, who would put the request on their priority list (ref. 3.2). This process entailed slower response time and increased possibilities for misapprehensions compared to the situation of maintaining an integrated, local team of support and development personnel.

A major problem related to the implementation of DHIS 1.3 in Vietnam was the absence of a working report generator (ref. 7.1.3). The report module in use had some serious flaws which the developer was unable to improve. The partner university refused to get involved in this episode and referred to the MS Access based DHIS 1.3 as being in conflict with their “open source profile”. This left the districts without the ability to produce output from the system, and was embarrassing for the HISP Vietnam organisation as they lacked the ability to improve the situation (ref. 7.1.3). These circumstances point out the importance of maintaining a capable support team. The mentioned episode with the report module differs significantly from the situation with the DHIS 2 report module, where contextual changes and adaptations are made regularly and systematic and long-term training is provided.

10.3.2 Cultivation of local learning processes

Cultivation of local learning processes is stated by Braa et al. (2004) to be vital for sustainability in IS implementations, and was emphasized by the HISP coordinators in Oslo as an important aspect of the DHIS 2 implementation process in Vietnam. Establishing mechanisms for training of local users in order to facilitate learning processes is obviously impracticable to achieve without the organisation being physically present at the local site. A main incentive for establishing a local development and support team was to facilitate and sustain such learning processes.

Braa (1997) describes cultivation in the field of IS as:

“Cultivation denotes a way of shaping technology that is fundamentally different from rational planning, engineering methods and construction of technology. Cultivation is about interfering with, supporting and controlling natural processes that are in the existing material (...)” (Braa 1997)

My apprehension of the notion of cultivation as *interference, support, and control of natural processes* implies from an education perspective the need for:

- Providing patient, long-term guidance regarding system usage on the premise of the users
- Giving the users the opportunity to practise individually and get *hands-on* experience while being supervised by the support personnel
- Giving the users help and support in their own working environment
- Building deliberateness around the intention and main objectives of the system implementation

The development and support team in HCMC has contributed to cultivation of local learning processes through a comprehensive training schedule. Firstly, training sessions has been conducted two days each month at the premises of the partner health centre in HCMC (ref. 9.10). Each unit, represented by two persons, goes through two training sessions. The first session gives the participants a background introduction of the HISP project and the DHIS 2 software, with emphasis on philosophy and main purposes. The session focuses further on installation of the system and basic usage like data entry, report generation and export and import of data. The training is based on a step-by-step procedure, where users are given sufficient time to complete their tasks, and progress is not made until everybody is ready to proceed. The second part of the first lesson gives the users some time to play and experiment

and get experience with usage of the system (ref. 9.10). During this part, the HISP workers are assisting users who need help and guidance. At the end of the day; an informal test is passed to the users in order to measure their acquired knowledge and get a pointer of the efficiency of the training schedule.

The second training session is considered a follow-up session, where users are given the opportunity to ask questions which have emerged during employment of the system since the initiation of the training (ref. 9.10).

Additionally, the HISP support personnel do follow-up on the hospitals and district offices by making monthly phone calls to check on their status (ref. 9.10). The units are also able to call the support personnel when needed. If technical trouble or questions regarding use have emerged, one person from the team travels to the unit that made the enquiry in order to help out (ibid).

These efforts are satisfying the previously mentioned conditions for cultivation of learning processes. The continued training sessions and follow-up provides for the necessary long-term guidance and hands-on experience, and the support personnel's visits to the hospitals and wards give the users training in their working environment. The part of the lectures covering the HISP philosophy and the intention and objectives of DHIS 2 gives the users a wider comprehension of the system implementation, and provides for the deliberateness needed in order to put their efforts with health information systems in a context.

The agreement between the Vietnamese Ministry of Health and HISP regarding the implementation of DHIS 1.3 and DHIS 1.4 stated that training and capacity building was a critical component of the implementation and had to be carried out at three levels (ref. 7.1.2):

- The health department would build capacity among their employees in order to make them able to run, maintain and troubleshoot the system on a daily basis.
- HISP would carry out training of workers from all units at district level regarding basic system functionality, maintenance as well as information management.
- Training addressing analysis and information management had to be performed in collaboration with health educational institutions.

The DHIS 1.3 implementation process was acknowledged to suffer from a shortage of technical personnel to support the implementation process (ref. 7.1.3), which implied that HISP was unable to accomplish the mentioned learning initiatives. This led to a deficit of skills and knowledge regarding the information system, which emerged to be a major contributing cause for its eventual failure. This incident stands out as a contrast to the DHIS 2 implementation where users are given regular training and follow-up; a factor that has to be regarded as contributing to its preliminary success.

Another point related to cultivation in terms of *supporting and controlling natural processes that are in the existing material* is that the remaining experiences from the DHIS 1.3 and DHIS 1.4 implementation processes among health workers in HCMC and Hue have made the training process easier for the development team. Even if the process eventually failed, it left many health workers with a basic concept and understanding of a health information system which could be used as a basis for further training.

“In Hue they use DHIS 1.4 already, and I just install and show them how to do the same thing in the new system.”

DHIS support worker in Hue

10.3.3 Establishment of persistent working routines

Experiences from each of the three DHIS implementation efforts in Vietnam described in chapter 7 has demonstrated a need for the following prerequisites for achieving persistent working routines:

- Support from the organisation management for system usage
- Ability to quickly improve flaws and make adaptations to local requirements
- Access to appropriate hardware
- Mechanisms for providing users with regular guidance and follow-up

Prior to the introduction of electronic health information systems in Vietnam the information flow was based on paper reports being filled out by the wards and hospitals and sent upwards to the next level in the hierarchy. The data would be aggregated at the above level and passed on to the next; a process which continued until the data reached the national level (ref. 7.1.2).

In HCMC, DHIS 2 was installed at the district and city level. The new working routines implied that personnel at the district offices received the paper based reports as earlier from the wards and entered the data into the DHIS 2 system. From there, the data would be exported to an XML file and sent to the city level for import (ref. 7.4.4). As of October 2006, the health department in HCMC is maintaining the paper based and the electronic report systems in parallel. They have stated that if DHIS 2 proves to be sustainable and satisfactory; they will phase out the paper based reports in favour of the electronic reports (ibid).

Firstly, the mentioned situation indicates that an important aspect of establishing persistent working routines is maintaining a stable and working system in order to obtain support from the health departments in the respective provinces for adopting the system into the daily work on a long-term basis. This implies that the DHIS 2 system must be able to perform the same tasks as the system it is intended to replace. The requirement for the report module to be able to produce exact replications of the existing paper based reports (ref. 8.3.3) illustrates this. If DHIS 2 proves to work over time, it will be accepted as an adequate replacement of the current paper based information system. Experience has demonstrated that users have stopped employment of the system because it was not able to perform the daily work. Upholding a competent local support team responsible for system maintenance and immediate support has turned out to be vital in order to achieve this.

*“- I have stopped using the system.
- Why is that?
- It can't print out the reports I want!”*

Conversation between HISP coordinator and health worker in Hue

Secondly, experiences from the DHIS 1.3 implementation process demonstrates that the ability to quickly improve system flaws and bugs and respond to requests for contextual

adaptations is crucial in order to gain confidence among users and uphold their incentives to use the system (ref. 7.1.3). If users experience frequent standstills related to system failures, they are likely to stop using the system and fall back to their familiar working routines (ibid). The need for a local development team to cater for these requirements has previously been discussed.

Thirdly, experiences from the DHIS 2 implementation in Hue shows that providing for appropriate access to hardware is important in order to achieve persistent working routines. Outdated computers not capable of operating DHIS 2 turned out to be a problem, and forced the implementation team to buy printers and memory cards in order to upgrade the hardware.

Fourthly, a comparison between the DHIS 1.3 and DHIS 2 implementation processes indicates that regular follow-up and the possibility for users to get help and support related to system usage when needed are improving the conditions for persistent working routines. The lack of user support and follow-up is acknowledged to be a major cause for the DHIS 1.3 implementation failure, while the close relation between the users and the HCMC support team is considered to be a contributing factor to the preliminary success of the DHIS 2 implementation.

10.3.4 Reproduction of learning processes and distribution of knowledge and technology

As previously stated, an aspect particular for information system within the health care sector is the need to scale up in order to be sustainable. Hence, as stated by Braa et al. (2004), important questions concern who learns what, and through what mechanisms, in order for an IS to spread to new sites and be scaled up.

The Vietnamese support team has turned out to be highly suitable as a mechanism for facilitating distribution of learning processes and technology. The support team consists of three members, which makes it possible for one or two persons to temporarily be located at other sites. The following section describes how the support team facilitates the mentioned distribution through a combination of physical presence and shared artefacts.

In August 2006 the Vietnamese support team started to expand the DHIS 2 implementation to the city of Hue (ref. 9.10). The training schedule has been fairly similar to one in HCMC, and is comprised by background information, demonstrations, individual practise and follow-up. Training is executed over three or four days, allowing for the users to reflect and get answer to questions that may have emerged. The main difference from the training schedule in HCMC is that training is done on-site at each ward or hospital, in order to ensure that installation is done properly. Hue only contains 9 districts, so for larger cities an approach with centralized training like HCMC will be considered.

In order to sustain the learning process after the support personnel travels back, the support team has created teaching materials in terms of an instruction video and a user manual (ref. 9.10) which describes basic usage of the system. This material makes it easy for health workers to revise their knowledge and provides a source for getting answers to questions about basic usage even if the support personnel is not present. Additionally, the personnel continue supporting the users through email and instant messaging after returning home.

To provide for easy distribution of artefacts the support team has assembled an installation package for the DHIS 2 solution. This package automatically installs the required database systems complete with the DHIS 2 database scheme as well as the necessary servlet container, web browser, Java Runtime Environment and user documentation. This package significantly simplifies the installation process, and allows for distribution of artefacts in terms of enabling health workers to install the system on their own without external guidance.

10.3.5 Disadvantages and challenges

Even if the establishment of the Vietnamese development team has demonstrated potential for improving sustainability in implementation and further development of DHIS; several challenges has emerged during the process, and the situation as of October 2006 is far from ideal. The following section will elaborate this subject.

Time and resource expenditure

Even if the establishment in early 2006 and work of the development team in HCMC has been fairly successful, the process leading to this event has been time-consuming and problematic. The mentioned process started as early as in January 2005. Since that, it has taken almost two years, several visits by HISP coordinators and a total of nine master students to establish a well functioning development team. A considerable part of these efforts has failed to sustain (ref.).

The purpose and vision of HISP is two-sided. Firstly, its primary goal is to design, implement and sustain HISs to support local management of health care delivery across developing countries. Secondly, HISP acts as an agent for creating knowledge and research material for the people involved in the project. Because HISP receives external funding and the master students carry out the work as “cultural mediators” (ref. 10.1.1) as part of their thesis and not as paid consultants, HISP is allowed to engage in such long-term projects without adhering to a cost-effective business model. The incidents during HISP’s first collaborative effort in Vietnam illuminate this (ref. 9.2):

The initial agreement between HISP and OutSoft, the partner company in HCMC, stated that HISP would get the opportunity to employ and pay cost price for a few of the interns engaged in the project in order to let them finish the work they had started on. At the end of the initial agreement period, OutSoft expressed that they were not satisfied with the progress of the DHIS pilot project, and as a result of this, they decided to withdraw the interns they had allocated. Claiming that HISP had misinterpreted the agreement; they offered HISP to hire the interns at the normal rate with a minor discount; which was turned down by HISP.

It later turned out that the major incentive for OutSoft to take part in the project was to eventually get in a position where they could provide commercial services around DHIS. This situation demonstrates that the HISP approach with incremental implementation processes and local capacity building is not considered as cost-effective by commercial companies.

However, in a research context; probably more important than being cost-effective is the need for long-term commitment. Collaboration with a commercial company is apparently vulnerable to market shifts. A main reason for OutSoft to withdraw their personnel from the project was that the demand for outsourcing services had rose to a high level, which implied

that they wanted to allocate their working power to profitable labour. Collaboration with the partner university is seemingly more stable and less exposed to such variations as the university maintains the same research interest as HISP in the project.

Conflicting agendas and interests

Still, both co-operation efforts have suffered from conflicting interests among the participants. As previously discussed, the interns at OutSoft did not want to participate in the implementation process since they were merely interested in software development and Java technologies, which made implementation and support of a MS Access based system less attractive. HISP was not able to fund separate teams for development and implementation, and relied on creating a team which was able to perform both tasks. This was also the case with the collaboration with the partner university as long as the DHIS 1 versions were employed. The university and the students were solely interested in free and open source technology, and did not want to engage in a proprietary system. This conflict was not solved until it was decided during the spring of 2006 that DHIS 2 would be employed in the implementation, and illustrates that university collaboration can suffer from contradictory interests and motivation. Moreover, this situation fits well with the viewpoints of Braa et al. (2004), who emphasise the importance of nurturing a robust, heterogeneous collection of actors likely to pursue distinct, yet similar agendas (ref. 2.2.3) in order to achieve sustainable implementation processes.

Lack of global contribution

As mentioned before, the students at the partner university's lack of exercise in independent problem solving (ref. 9.6.1) has demanded a huge effort from the Norwegian master students in terms of training and follow-up. This effort has resulted in a capability to develop local, context-sensitive functionality, which is sufficient in order to maintain and sustain the system. On the other hand, the students have not been able to contribute on a large scale to the global solution. Some efforts to develop global functionality, e.g. a user administration module, have been attempted (ref. 9.10). Even if this attempt resulted in a partially working service module, a major effort from one of the core developers in terms of assistance and guidance in order to complete it turned out to be necessary.

HISP maintains a long-term goal of moving the core development responsibility out of Norway. Still, as of October 2006, the approach of establishing a local development team in Vietnam can not be considered as effective regarding contribution to the global development process. The members of the team have a long way to go regarding this capability, and employing a professional full-time IT developer in Oslo would probably have resulted in a higher code production for DHIS 2. Still, this approach would not have been appropriate in terms of requirements gathering, proximity to the user domain, adaptations of the system to the local context, as well as other vital conditions for sustainability previously discussed in this chapter.

Complex user domain

The user domain in which the Vietnamese development team operates is demanding in terms of its complex nature. Knowledge and insight within both health management and information technology is vital in order to sustain and further develop the usage of DHIS 2. As of October 2006; the potential in a computerised health information system such as DHIS 2 is to a low

degree exploited in Vietnam. Still, the usage of the system is limited mainly to data entry, data transmission between levels in the health hierarchy and generation of reports containing the same data as the previously used paper based versions. A main incentive of keeping an electronic HIS is to provide for flexible and dynamic analysis of data in order to improve the conditions for a reasonable and effective distribution and allocation of health resources. HISP aims at improving the application of DHIS 2 through more advanced and useful employment of the system in terms of i.a. integration of sophisticated external tools for data analysis. Additionally, a goal linked to the overall vision of HISP is to support local management of health care delivery and information flows (ref. 3.1) and local use of data at the district level.

The HISP personnel in Vietnam is predominated by people with technical backgrounds. Even if the members of the development team are improving their skills through interaction with users; they still lack the extensive experience and authority necessary for influencing and improving working routines among health workers, as well as obtaining support from the MoH for transferring control of information systems from central towards local levels, i.e. to health managers at district offices. The exception is the HISP coordinator in Vietnam who is a medical doctor and head of department for community health and works in a local medical university. On the other hand, he has minor skills and practical experience with information technology.

10.3.6 Summary of local development teams as a means for sustainability in IS implementations

In the following section I will summarize my findings regarding local implementation and development teams as a means for improving sustainability in information systems implementations.

My analysis has demonstrated that, in a global software development setting, local development teams are suitable mechanisms for accomplishing the previously mentioned conditions for sustainability and scalability maintained by Braa et al. (2004).

- When maintaining a social perspective on information systems; local development teams are favourable for requirements gathering and adaptation of systems to a local context as it facilitates local participation and contact with users.
- A local development team is adequate for contributing to cultivation of learning processes through long-term training, guidance to individual experience, follow-up of users in their own working environments, and building of deliberateness.
- Local development teams are appropriate as a means for establishing persistent working routines through the ability for improving flaws and making adaptations to local requirements, providing access to appropriate hardware, providing users with regular guidance, and indirectly obtain support from the organisation management.
- A local development team is suitable as a mechanism for reproduction of learning processes and distribution of knowledge and technology through a combination of physical presence and shared artefacts.

Even if the establishment of the Vietnamese development team has demonstrated potential for improving sustainability in implementation and further development of DHIS; several challenges has emerged during the process and, as of October 2006, the situation is far from ideal.

- The process leading to the establishment of the development team has been costly in terms of time and resources.
- The process has suffered from participants with conflicting agendas and interests; which made the goal of maintaining a combined implementation and development team hard to achieve.
- The development team has despite its important role for the local implementation not been able to contribute significantly to the global development.
- The approach of hiring IT students has not been appropriate in terms of improving application of the health information system and support local management and use of data.

10.3.7 Benefits from global software development in local implementation processes

In this section I will account for how the global HISP community has benefited local implementation processes in Vietnam.

Software

The Vietnamese Ministry of Health has through its collaboration with the global HISP development project been able to benefit first of all from the DHIS application suites. The software comes free of charge and the DHIS 2 system is independent of proprietary frameworks in order to run. The system is continuously and frequently updated and maintained on a voluntary basis in order to support emerging requirements from the users.

Human resources

Several of the Norwegian master students doing fieldwork in Vietnam have contributed to the DHIS implementation process through workshop arrangements (ref. 9.6.4), specific implementation work like installation and user training, and as “cultural mediators” (ref. 10.1.1) in order to facilitate communication between the users of the system, the MoH and the HISP coordinators in Oslo. Human resources in the HISP project like the project leader and the project coordinators possess extensive knowledge and experience in terms of approaches to system implementations in developing countries. This experience has been of great value for the collaboration with the Vietnamese MoH regarding the DHIS implementations. Additionally, HISP maintains an extensive community consisting of people with varying background, like health workers, medical doctors, and software developers. A considerable part of the communication between these actors takes place on the DHIS mailing lists. Participation in this community can be of great value for the DHIS actors in Vietnam in order to obtain knowledge in the health information system domain, improve their application of the system and learn from relevant experiences in other countries. E.g. the HISP implementation in India reveals challenges and appropriate solutions which are likely to be useful for the Vietnamese implementation in the future.

11 Conclusion

In this chapter I will summarise my research, attempt to draw conclusions of general validity, and make some concluding remarks.

Research question 1: *Explore challenges and solutions regarding ICT capacity building in developing countries through participation in global software development.*

The first research question has been explored by drawing on my experiences from establishing a local development team in Vietnam and global software development within the DHIS 2 network more generally. Through a validation of the DHIS 2 project against acknowledged best practises and framework for analysis for distributed development provided by Lings et al. (2006), I have revealed strengths and weaknesses and appropriate strategies for improving HISP's approach for global software development. Additionally, I have presented the lessons learned from my efforts for ICT capacity building in Vietnam. I have pointed out that political aspects like the Vietnamese IT sector's lack of interaction with foreign companies and universities influenced the partner university's interest for international collaboration in a positive direction. Also, the release of a functional DHIS 2 version entailed realistic environments for software development, and facilitated demonstration of the system and development of new modules.

We have seen that local capacity building can benefit from participation in global software development projects in terms of realistic environments for software development and access to a global network of human resources and shared best practises.

I have contributed to the discourse on software development capacity building firstly by demonstrating that combining software development with implementation support entails comprehension of the user domain and training in requirements management, which are vital skills for developers and for the ability to adapt a system to a local context in particular. The other way around, involving an implementation team in the development process of a system leads to personal ownership and commitment among the personnel, which entails motivation for getting a working system into use. Secondly, I have demonstrated that exposure to requirements and feedback from users of a functional system forces practical, independent problem solving, which in turn is likely to increase learning.

Research question 2: *Explore challenges and solutions regarding adaptation of information systems to local contexts while maintaining global requirements.*

The second research question has been discussed in elucidation of my experiences from global software development within the DHIS 2 network in general and the development of a report module in Vietnam more specifically. My discussion has used the theories of Rolland and Monteiro regarding balancing local and global requirements in infrastructural information systems as point of departure. In the analysis I have investigated the process of adapting the mentioned report module to a local context.

I have contributed to this discourse by demonstrating that making solutions to local requirements as general as possible allows for including the functionality in the global solution and avoiding maintenance of local branches, and hence curb local-global tensions. Additionally, I have proved that flexible solutions to local requirements can benefit the global

network if similar requirements are likely to emerge at other nodes. Eventually, I have pointed out that developing general solutions implies a higher cost in terms of labour compared to local and specific solutions.

Research objective: *Explore how global software development and local capacity building can improve sustainability of information system implementations in developing countries.*

I have addressed my research objective through drawing on experience from my Vietnamese case study. My analysis has demonstrated that local development teams are suitable mechanisms for accomplishing the conditions for sustainability and scalability maintained by Braa et al. (2004). When maintaining a social perspective on information systems in a global software development setting, I conclude that establishment of local development teams is a favourable approach for local requirements gathering, contextual adaptations and cultivation of local learning processes and thus for improving sustainability and scalability in information system implementations. Additionally, I have demonstrated that local implementation processes can benefit from participation in global software development projects in terms of human resources and accessibility to free software.

However, several challenges emerged during the team building process, and the situation as of October 2006 implies certain disadvantages. The process leading to the establishment has been costly in terms of time and resources, and has suffered from participants with conflicting agendas and interests making a combined development and implementation team hard to achieve. The development team has despite its important role for the local implementation not been able to contribute significantly to the global development. Additionally, the approach of hiring IT students has turned out to be inappropriate in terms of improving application of the health information system and support local management and use of data.

My research objective has been illuminated by the first research question through its focus on challenges and solutions to the pragmatic aspect of local capacity building. The second research question has contributed to the research objective by suggesting strategies for balancing adaptation of information system to local contexts and adherence to global requirements; which is a vital prerequisite in order to benefit from global resources while establishing a working local information system.

Finally, the action research approach chosen for this thesis has proven to create local knowledge and insight necessary for understanding the research areas. Close collaboration with local stakeholders including training, genuine problem-solving, and discussions provided me with knowledge that could not have been achieved through a more traditional research approach.

12 Acronyms and abbreviations

AIDS	Acquired Immunodeficiency Syndrome
AR	Action Research
ASCII	American Standard for Information Interchange
ASEAN	Association of Southeast Asian Countries
BIRT	Business Intelligence and Reporting Tools
COMECON	Council for Mutual Economic Assistance
DD	Distributed Development
DHIS	District Health Information Software
EDS	Essential Data Set
FOSS	Free and Open Source Software
GKP	Global Knowledge Partnership
GMT	Greenwich Mean Time
GNU	GNU's Not Unix
GSD	Global Software Development
GUI	Graphical User Interface
HCMC	Ho Chi Minh City
HIS	Health Information System
HISP	Health Information Systems Programme
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information Software
HTML	Hypertext Markup Language
ICT	Information and Communication Technology
IS	Information System
IST	Information System Technology
IT	Information Technology
J2EE	Java 2 Enterprise Edition
JDBC	Java Database Connectivity
JRXML	JasperReports Extensible Markup Language
LGP	GNU Lesser General Public License
MDG	Millennium Development Goals
MoH	Ministry of Health
MoH	Ministry of Health
MoU	Memorandum of Understanding
MS	Microsoft
MVC	Model View Controller
ORM	Object Relation Mapping
OSS	Open Source Software
PAHO	Pan American Health Organization
PDF	Portable Document Format
PHC	Primary Health Care
POJO	Plain Old Java Object
POM	Project Object Model
PVC	Communist Party of Vietnam
RHINO	Routine Health Information Network
SCM	Software Configuration Management
SDC	Swiss Agency for Development and Cooperation
SQL	Structured Query Language

UiO	University of Oslo
UML	Unified Modelling Language
UN	United Nations
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UTF	Unicode Transformation Format
VB	Visual Basic
WHO	World Health Organisation
WITFOR	World Information Technology Forum
XLS	Excel Style Sheet
XML	Extensible Markup Language

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Vilnius Declaration

Appendix A

This appendix describes selected parts of my contribution to DHIS 2. Minor parts of the explanations require certain previous knowledge in the DHIS 2 development frameworks.

A demonstration of the current version of DHIS 2 is running at <http://www.hisp.info:8090>

Username: admin

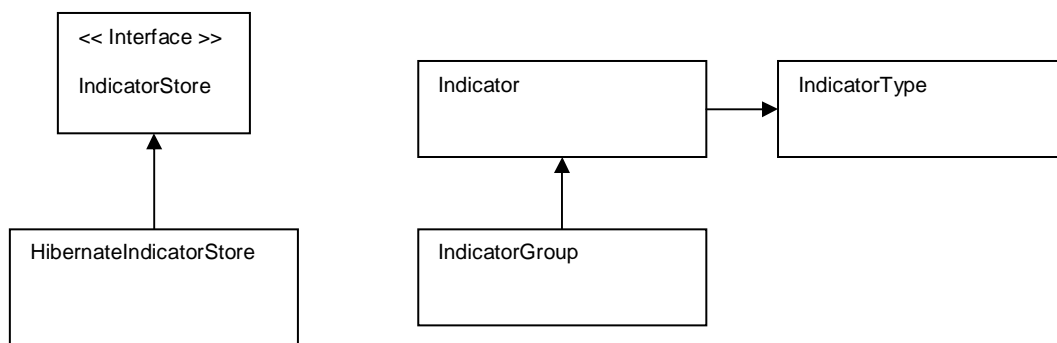
Password: district

1. Indicator store

An indicator is an object intended to describe the state of a medical phenomenon. The content of an indicator is defined in an indicator formula. An example of an indicator is:

Postnatal HIV positive rate = Postnatal clients HIV positive / Postnatal visit at 6 weeks

The indicator store serves the duty of adding, updating, retrieving and deleting indicator objects in the data base. The indicator store interface contains 21 methods, and is realised by a Hibernate implementation. When the indicator object was integrated in DHIS 2 it contained only four properties; today growing requirements has led to a total of 13 properties.



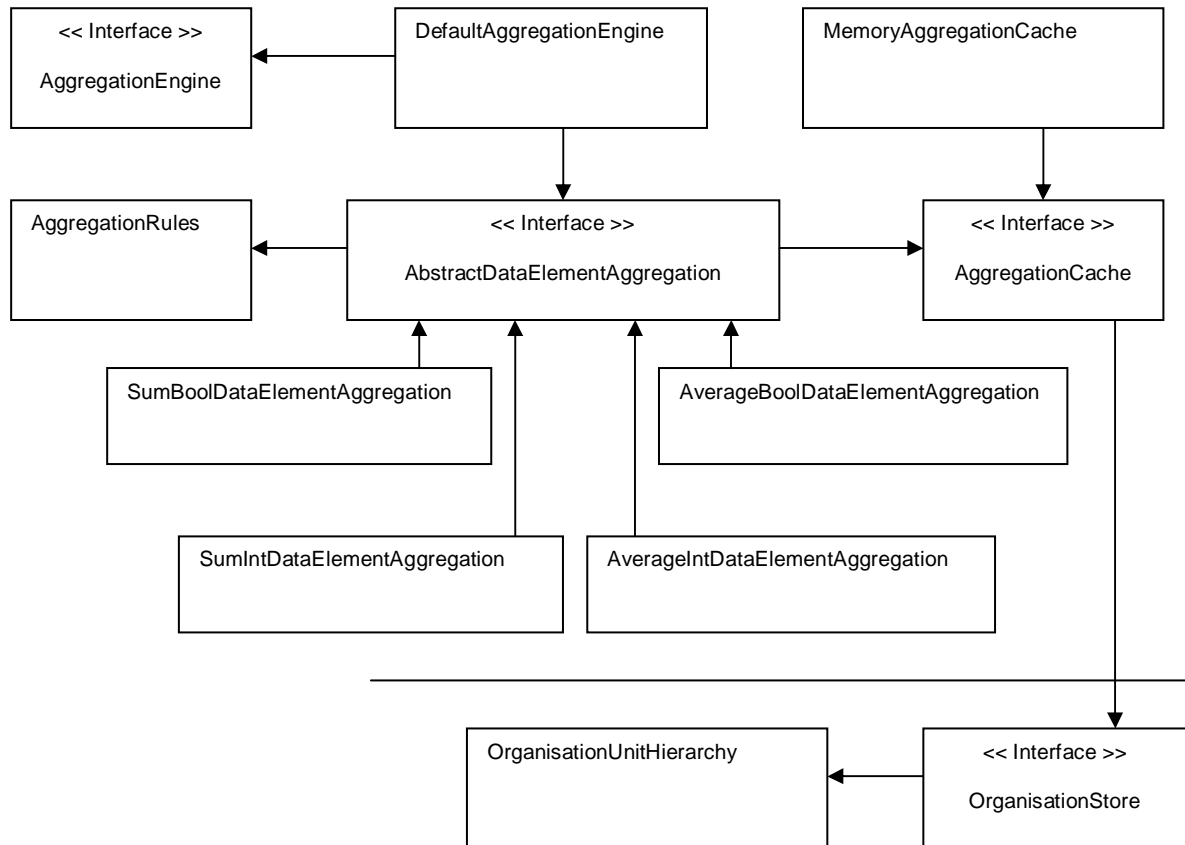
Class diagram of the indicator store

2. Aggregation engine

As the name implies; this module is responsible for aggregation of data. In DHIS 2; data can be aggregated over periods of time and downwards in the organisation unit hierarchy. This implies that an organisation unit can get the aggregated data value for all of its sub units; given a data element and a start- and end date. The requirements and strategy for aggregation emerged through a long period of prototyping, user feedback, and discussions with the developers of the DHIS 1.4 system.

Three requirements were implying technical challenges during the development. Firstly, the requested aggregation period would not necessarily match the start- or end date of any data

input periods. This was allowed for through a flexible model for aggregation of periods. If an aggregation period overlaps a data input period with a number of days, the data value registered for this period is simply multiplied with the mentioned number of days and divided on the total number of days in the period.



Class diagram of the aggregation engine

Secondly, the engine must allow for alteration in the organisation unit hierarchy. If an organisation unit moved in the hierarchy, the data registered for that unit still had to be included if an aggregation period previous to the move was requested. In order to achieve this; the engine stores the state of the organisation unit hierarchy every time a move takes place. When an aggregation period spanning a change in the hierarchy is requested, the aggregated value for the period between the start date and the alteration date, and the alteration date and the end date are processed separately and eventually summarized. Since this implied a performance cost, I decided to include a cache level for the functions that retrieved the hierarchy state objects from the database. This cache is realised with a memory implementation, which simply puts every retrieved object into memory for faster retrieval when the object is queried later.

Thirdly, the nature of data elements implies that some should be aggregated with the sum operator while some with the average operator. E.g. over several periods; the number of *postnatal visits* has to be summarized while one has to find the average of a total body count in an area. Additionally, data elements can be defined as either of type *boolean* or *integer*, which in turn requires different logic for aggregation. In order to achieve this; I decided to

adhere to the design principle of *encapsulating what varies*. I designed an abstract data element aggregation class with common aggregation functionality across *operator* and *type*, which was extended by four classes that represented each combination of the mentioned properties and provided the particular functionality.

3. Data dictionary

The data dictionary module contains user interfaces for handling of data elements and indicators. The image presented below relates to handling of the numerator in an indicator formula. The user interface provides an input field for numerator description and a check-box list for aggregation operator. Data elements can be added to the numerator by double-clicking in the data element list. Data elements can be filtered by name in the input field above and sorted by group in the drop-down list. The formula can be defined by adding mathematical operators through clicking their respective icons under the formula area. A readable numerator formula description is updated on the fly at the bottom.

http://www.hisp.info:8090 - DHIS 2.0-M6-SNAPSHOT - Mozilla Firefox

District Health Information Software 2.0

Antenatal HIV testing rate

Numerator description	Aggregation operator
Antenatal HIV positive	<input checked="" type="radio"/> Sum <input type="radio"/> Average
Numerator	List of data elements
([8]+[7]) () * / + - Update Close	Filter by name: [Filter by group/view all] AN AZT side-effects AN HIV pos CD4 <200 AN HIV pos CD4 >=200 AN HIV positive AN HIV positive CD4 AN HIV tested AN discount. AZT AN pre-test counselled AN started AZT AN started HAART
Numerator description	
(Antenatal client HIV positive with CD4 count <200+Antenatal client HIV positive with CD4 count >=200)	

User interface for handling of the numerator in an indicator formula

The described functionality in the data dictionary module is communicating directly with the indicator store in order to update the database.

4. Datamart

A data mart is kind of a data warehouse where data is aggregated and exported to dedicated tables in the database. The datamart functionality consists of a service module and a web module. The web module provides a simple interface for inexperienced users and an advanced interface for expert users.

The screenshot shows a web browser window with the address bar displaying `localhost:8080/app/dhis-web-datamart/getSimpleOptions.action`. The page title is "DHIS2 Software 2.0" and the user is "Not logged in". The main content area is titled "Simple Data Mart export". It features two columns of selection options. The left column, "Available data types", has a text box containing "Indicators". Below it, "Available levels" lists "Level 1", "Level 2", "Level 3", and "Level 4". The right column, "Selected data types", has a text box containing "Dataelements". Below it, "Selected levels" lists "Level 6" and "Level 5". Between the columns are five buttons: ">", "<", ">>", "<<", and "><". At the bottom, there are two date input fields: "Start date (yyyy-mm-dd)" with the value "2006-01-01" and "End date (yyyy-mm-dd)" with the value "2007-01-01". Below these are two buttons: "Export" and "Clear".

Simple user interface for export to datamart

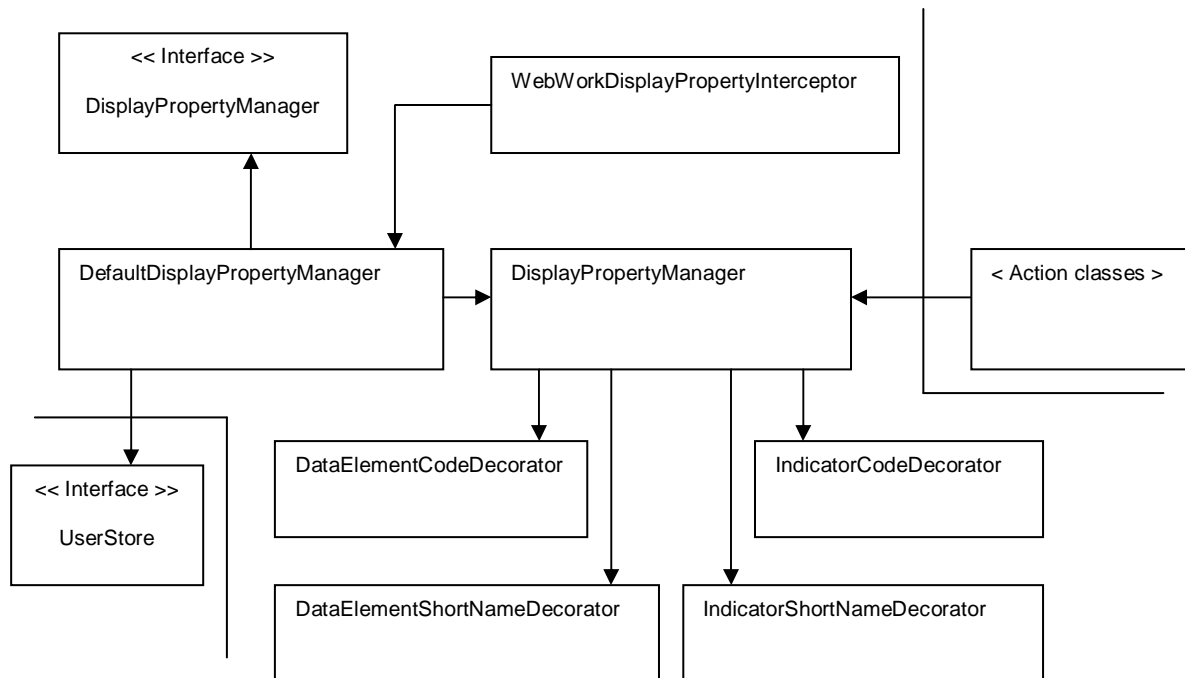
The simple interface provides the user with options for selecting which data types, i.e. data elements and indicators, organisation unit hierarchy levels, and period of time to include in the export to the datamart. The advanced export interface lets the user specifically pick out which data elements, indicators, organisation units and periods to export.

The web module depends on the datamart service module, which provides methods for achieving the previously described functionality. The data mart service is basically iterating over the requested data elements or indicators, organisation units and periods and writes an aggregated data value to the database for each possible combination. The aggregation engine is used to calculate the aggregated data value, which additionally contains properties for data element or indicator name, period name, period type name, organisation unit name and level.

5. Options module

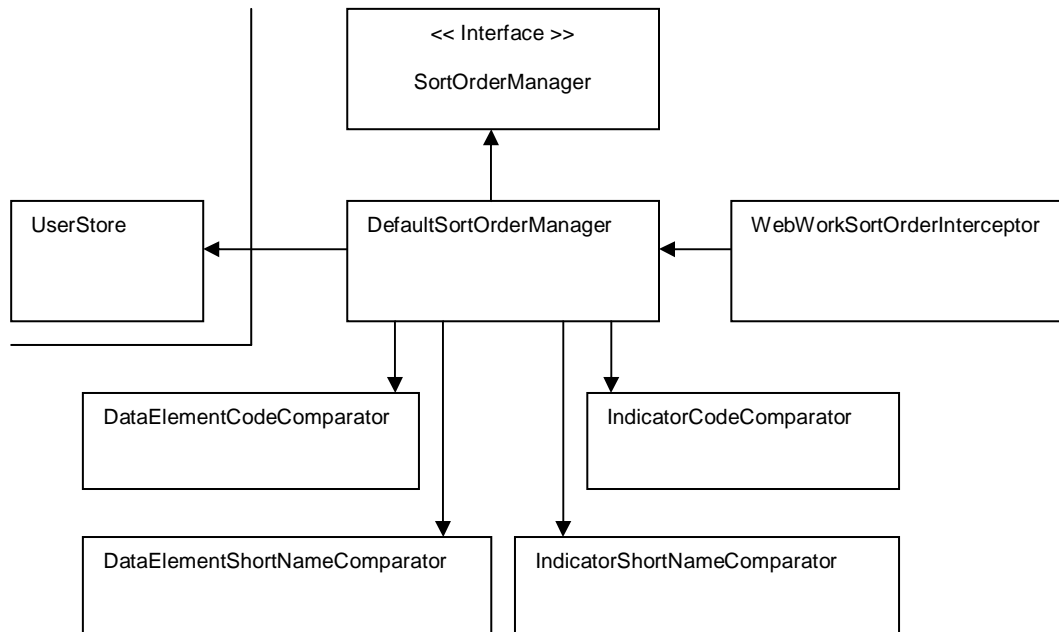
The purpose of the options module is to contain functionality related to user settings. Firstly, the module provides functionality which allows users to select which property of the data element and indicator object to display in lists. The user can currently select between name, alternative name, short name, and code.

The display property manager is responsible for retrieving the display property setting of the current user. When asked, the manager creates a display property handler, which is passed a display property through the constructor. The display property manager is responsible for decorating and returning a given list of data elements or indicators in such a way that the value of the name property is replaced by the value of the display property. The *decorator design pattern* is applied to achieve this functionality. The display property handler is made available to the action files in the presentation layer through the display property interceptor, which is responsible for pushing the mentioned object onto the XWork value stack.



Class diagram for the display property solution in the options module

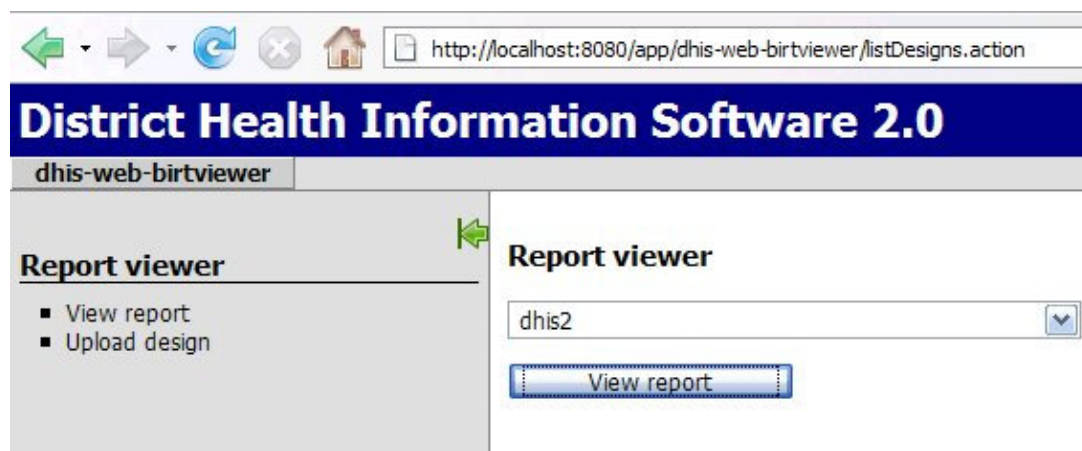
Secondly, the module provides functionality which allows users to select the sort order for the lists of data elements and indicators. The user can currently select between name, alternative name, short name, and code. The sort order manager is responsible for retrieving the sort order setting of the current user. When asked, the manager instantiates an applicable comparator and returns it. The comparator is made available to the action files through the sort order interceptor. The action files containing lists of data elements or indicators use the comparator for sorting the lists according to the setting of the current user.



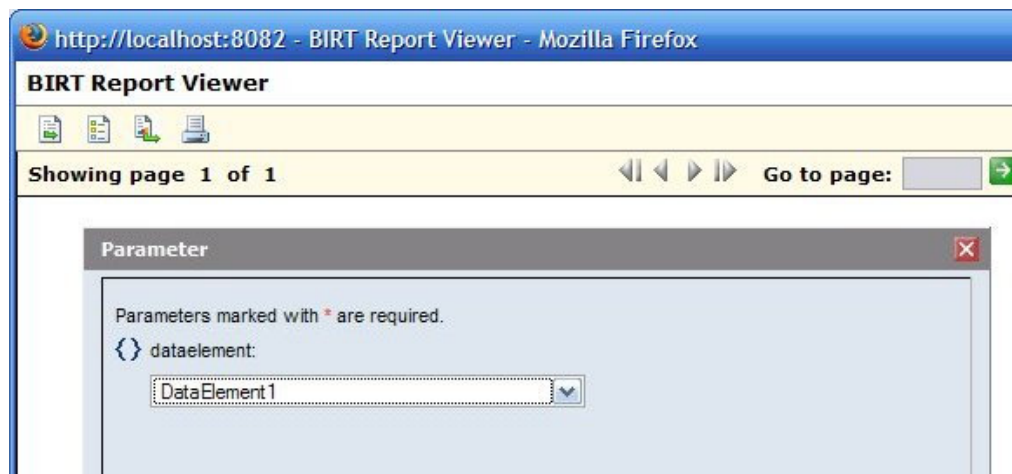
Class diagram for the sort order solution in the options module

6. BIRT report viewer

BIRT, an acronym for Business Intelligence Reporting Tool, is developed by the Eclipse foundation and is an open source reporting framework suitable for dynamic reports in terms of report layout, data access and scripting. The BIRT report viewer module takes advantage of a pre-built web application included in the release, which can generate reports based on a design file by passing the necessary parameters through a URL. The module is responsible for allowing the user to specify the location of the BIRT web application, upload report design files and redirect to the appropriate URL.



BIRT report viewer user interface



The BIRT web application parameter input form

7. Organisation Unit Management

My contribution to the organisation unit management module is related to organisation unit group sets. The group set object contains, besides a set of organisation unit groups, a name, a description, a *compulsory* property and an *exclusive* property. Compulsory implies that all organisation units are required to be a member of one of the groups in the group set.

Exclusive means that organisation units can only be a member of one of the groups in the group set. This entails that certain validation rules has been integrated. E.g. when adding or updating an exclusive group set; the system checks whether any units in the selected groups is a member of more than one group. Additionally, when adding or updating a group which is a member of an exclusive group set, the system verifies that the selected units are not a member of another group in the group set.

User interface for editing an organisation unit group set

Appendix B

The DHIS License

DISTRICT HEALTH INFORMATION SYSTEM MODULES - END USER LICENSE AGREEMENT

LICENSE. The Health Information Systems Programme (HISP) is a collaborative research & development network comprising Universities, Ministries, and not-for-profit companies in countries like South Africa, Mozambique, Malawi, Tanzania, Ethiopia, India, Vietnam, Norway, and Sweden (the network is continuously expanding).

HISP grants you a non-exclusive license to use the DHIS software modules, provided the use is exclusively for non-commercial purposes. The term "DHIS modules" includes any upgrades, modified versions, or updates of the DHIS application provided to you from HISP or its partners.

You may make and distribute unlimited copies of the software, including copies bundled with commercial products, as long as each copy that you make and distribute contains this Agreement and is distributed for free. If you enable the download of DHIS modules from the Internet or similar online source, you must include this Agreement with any online distribution and on any media you distribute that includes the software. You are free to modify, translate, or create derivative works based on the DHIS software, again provided that this End User License Agreement is attached to the DHIS parts of these works and that such parts are provided for free.

All developers are encouraged to provide such modifications, enhancements or derivative works to bona fide users on a non-commercial basis.

DISCLAIMER OF WARRANTY. The HISP project has done its best to ensure the quality and correctness of the DHIS software, including incorporating functionality requested by users. Note, though, that the DHIS is provided on an "AS IS" basis, without warranty of any kind, including without limitation the warranties of merchantability, fitness for a particular purpose and no infringement. The entire risk as to the quality and performance of the DHIS modules are borne by you. Repair of discovered bugs, as well as the incorporation of new features, will in the (unlikely) event of the HISP network dismantling be the responsibility of the users or software designers appointed by users to maintain and/or further develop the software, unless HISP already has vested this responsibility in another body (e.g. a University department). Data exported from the system, using XML and/or comma-delimited TEXT files in ANSI or Unicode (UTF-8) format, have been standardised on the "yyyy/mm/dd" format in accordance with ISO-8601. Users importing data from DHIS into non-PC systems are responsible for designing import routines that correctly interprets the standard "yyyy/mm/dd" date format.

TERMINATION. The license will terminate automatically if you fail to comply with the limitations described herein. On termination, you must destroy all copies of the DHIS software.

LIMITATION OF LIABILITY. UNDER NO CIRCUMSTANCES AND UNDER NO LEGAL THEORY, TORT, CONTRACT, OR OTHERWISE, SHALL HISP OR ITS COLLABORATING PARTNERS BE LIABLE TO YOU OR ANY OTHER PERSON FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY CHARACTER INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF GOODWILL, WORK STOPPAGE, COMPUTER FAILURE OR MALFUNCTION, OR ANY AND ALL OTHER COMMERCIAL DAMAGES OR LOSSES.

MISCELLANEOUS. If the copy of the Software you received was accompanied by a printed or other form of "hard-copy" End User License Agreement whose terms vary from this Agreement, then the hard-copy End User License Agreement governs your use of the Software. This Agreement represents the complete agreement concerning this license and may amend only by a writing executed by both parties. This Agreement is governed by the laws of the Republic of South Africa.

Appendix C

Memorandum of Understanding

Between

The Planning and Financial Department of the Ministry of Health, Vietnam

and

The Health Information Systems Program (HISP) and BEANISH, Department of Informatics,
University of Oslo, Norway

Collaboration on Health Information Systems, Open Source Software development and capacity building in Vietnam

Agreement

This is a Memorandum of Understanding (MoU) between the Planning and Financial Department of Ministry of Health, Vietnam and HISP/BEANISH, University of Oslo, Norway, to

- 1) collaborate on developing and implementing a Free and Open Source district based Health Information System (DHIS) in Vietnam, and to
- 2) strengthen the capacity in this area and in the area of health information systems more generally in the Ministry of Health and in Vietnam.

The project will work closely with the Ministry of Health and will in an initial phase be implemented and tested out in Ho Chi Minh City, Hue Province, Hanoi City and in other selected provinces.

Given the Vietnamese Government's strategy to move public sector software to open source, the aim is to develop a fully open source software application for the collection, processing, analysis, communication and dissemination of health information in Vietnam. The MoH, Vietnam, is by this MoU becoming a partner in the open source software development within the HISP and BEANISH comprising a number of countries in Africa, (e.g. South Africa, Botswana, Mozambique, Tanzania, Ethiopia) and Asia (India). The African partners in HISP have come together and formed the BEANISH project under the EU Commission's 6th Framework Program.

Vietnam and the MoH is partner in a proposal submitted to the EU to establish an extension of BEANISH in Asia together with Thailand, India, China and Mongolia.

The HISP network has since 1997 developed the MS Office based District Health Information Software (DHIS 1.4), which is the national standard in South Africa and which is also running in a number of other countries such as India. Building of the knowledge and specifications embedded in the DHIS 1.4, HISP/BEANISH is now developing a fully open source software

application based on Java frameworks named DHIS 2.0. This MoU seeks to establish Vietnam and the MoH as a key partner in this development.

The MoH has developed the HMIS, an Access based software application, including the data and reports required by the MoH. In a parallel process HISP-Vietnam has customized the DHIS 1.4 to the conditions in Vietnam and implemented the software in Hue Province and in Ho Chi Minh City. While the strength of the HMIS is that it is fitting to the requirements for data and reporting of the MoH, the strength of the DHIS is its flexibility and capability to analyse and evaluate data. Building on the strength of both applications, the first step in the project, the pilot phase, is to merge the HMIS and the DHIS and gradually include the Open Source modules as they are finalized, before finally the whole application is fully Open Source. This work will be carried out in Hanoi City, Hue and HCMC and other selected pilot provinces. As a step 2, after evaluation and acceptance, the fully open source DHIS 2.0 will be implemented countrywide. The following is an outline of the two steps (see figure):

STEP 1: Merge the HMIS and the DHIS 1.4 in a combined and integrated software application suit. This will be carried out in selected pilot provinces and cities. The independent modules of the open source project will be added and integrated with the merged application as they are being finalized. Examples of such modules are; report generator, web-presentation of information and reports, map based Geographical Information System (GIS). When the Open Source DHIS 2.0 is ready it will gradually replace the merged HMIS/DHIS application. Then follows evaluation.

STEP 2: When the DHIS 2.0 is ready, tested and evaluated it will be implemented country wide. DHIS 2.0 will include a number of other modules and functionalities, such as web-based user interface for data entry and access to data, information and data analysis. However, given the fact that many parts of Vietnam will have insufficient band-width and connectivity, DHIS 2.0 will allow for a mixture of stand-alone and web-based applications.

Support from HISP/BEANISH:

HISP/BEANISH will support MoH in developing strong capacity in health information systems and open source software development by

Employ one person who will work for the MoH in Hanoi. This person will work on the HMIS/DHIS merged software application and support the implementation of this software first in Hanoi City and thereafter in other provinces. This person will be trained by HISP and work closely with the team in HCMC and Hue.

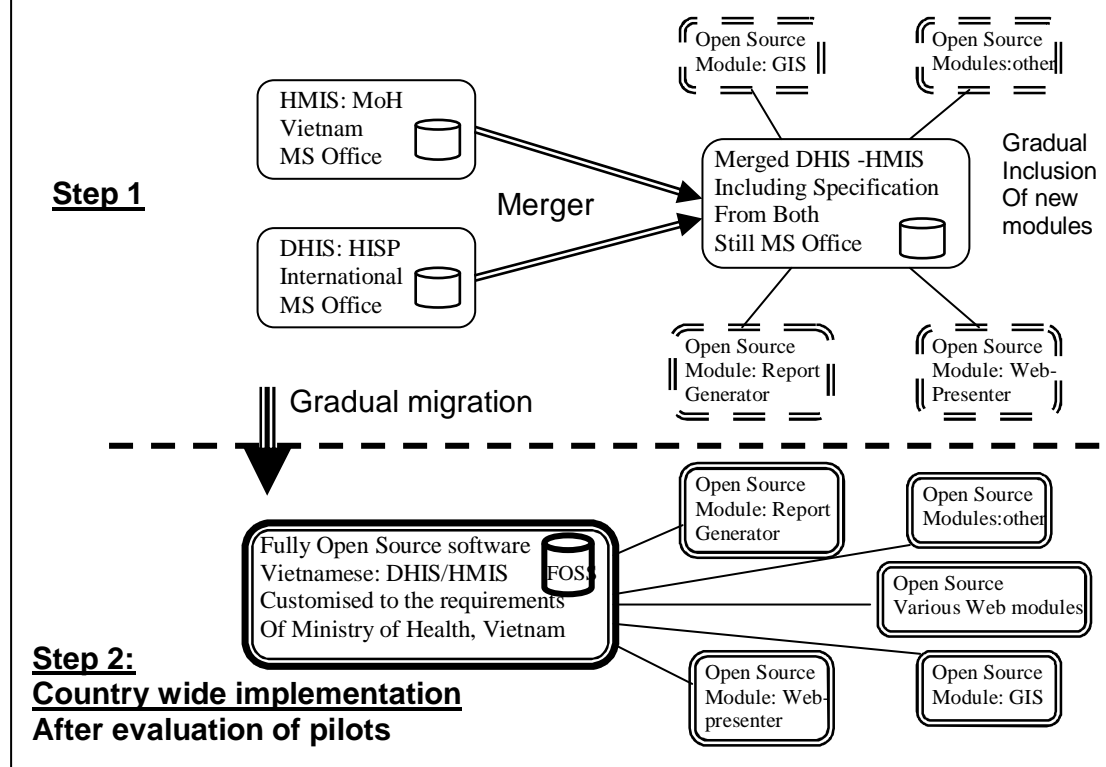
Support capacity development and training of staff at the MoH working on the HMIS/DHIS and open source development.

Develop project proposals together with the MoH for additional resources to the project. The BEANISH Asia proposal submitted to the EU is part of this work.

Support the work in the pilot provinces and cities.

Support the country wide implementation of the Vietnamese Open Source Health Information Software Application DHIS 2.0.

Plan for collaboration MoH, Vietnam and HISP/BEANISH
Free and Open Source Software



Signature.....Date: 7 November 2005
 Dr. Duong Huy Lieu , Director, Planning and Financial Department, Ministry of Health, Vietnam

Signature.....Date: 7 November 2005
 Associate Professor Jorn Braa, Department of Informatics, University of Oslo, Norway.
 Coordinator of HISP/BEANISH

Appendix D

Agreement

between

The Ho Chi Minh City Health Department, Vietnam

and

The Health Information Systems Program (HISP), Department of Informatics, University of Oslo, Norway

Collaboration on Health Information Systems and Open Source Software development and capacity building in Ho Chi Minh City

Agreement

This is an agreement between the Ho Chi Minh City Health Department and HISP, University of Oslo, to collaborate on developing and implementing a district based Health Information System (HIS) in Ho Chi Minh City. All 24 districts in HCMC will be targeted and Mother and Child Health data will be the first area of intervention.

HISP will further develop and adapt the Open Source District Health Information Software (DHIS) to suite the needs of HCMC Health department and implement DHIS in all the districts in HCMC. The HCMC Health Department will participate in this task by allocating staff from the informatics unit to work with the development team.

Revising data standards, reporting formats and routines are important parts of the software development and implementation process. HISP will assist the HCMC health Department in this work. The HCMC Health Department allocates health program managers and other relevant personnel to take part in this work.

Training and capacity development are critical component of the implementation and need to be carried out at three levels:

- a) The HCMC informatics unit needs to be able to run, maintain and “trouble shoot” the system once it is implemented. This capacity will be developed by ensuring strong participation from the HCMC Health Department’s Informatics unit in all stages of software adaptation and implementation.
- b) Training of staff responsible for the system at district level. A minimum of two people from each district needs to undergo training in basic system running and maintenance as well as in managing the information, making reports etc. This needs to be organised as training courses. The HCMC Health Department will organise the courses and HISP will conduct the training.

c) In addition to the basic technical capacity to run the system training will also need to address analysis and use of information for management and health services delivery. This will need to be done in collaboration with a health educational institution, such as the Ho Chi Minh City Medical Staff Training Centre.

Organisation – project team

The project is based at the HCMC Health department and the project team consists of representatives from the Health department; the Informatics unit, health management and 2-3 districts, and from HISP; both from Norway and local partners.

Contributions from HISP

The DHIS is developed by the international HISP network and is Open Source and provided free of costs.

Development and adaptation of the DHIS software in Vietnam is carried out by HISP in collaboration with TMA Solutions which is one of the Vietnamese HISP partners. This work is also provided free of costs. The BAKCO Company is also expected to take part in this work.

HISP has some basic funding through the Norwegian Government and the Norwegian participation in the project will be free of costs for the HCMC Health Department.

HISP is responsible for software, implementation and to conduct the training.

Contributions from the HCMC Health Department

The HCMC Health Department will allocate staff from the Informatics unit, health management and districts to the project team.

The HCMC Health Department is responsible for organising the training sessions (venues, participants, equipment) when the system is to be implemented in all districts.

The HCMC Health Department is responsible for the technical infrastructure. The project will implement the system on the computers and network that is being planned and currently implemented in the districts in HCMC.

Tentative plan for the first phase

The project starts in October 2004. During 2004 the project will

- establish the project group
- develop a plan
- revise the data sets on Mother and Child Health to be used in the first database version
- organise the population / demographic data to be included in the database
- identify the key indicators to be included in the database
- define the key reports to be produced by the system
- based on the above, develop a first DHIS database application based on conditions and needs in HCMC and test it in a few districts
- during October: write a more detailed plan

Background: the Health Information Systems Programme (HISP)

HISP is an international research and development programme established as collaboration between health authorities and universities in a number of countries. Starting in South Africa

in 1994, HISP has since 1999 developed into an international network including Mozambique, Malawi, Tanzania, India and Ethiopia. Vietnam is now being included as a partner in the HISP network.

The Open Source DHIS software was first developed in South Africa and has been implemented in all districts and hospitals in that country since 1999. The national implementation in South Africa was funded by USAID. The achievements and strong resource base in South Africa have been important for building the international HISP-network and the work in other countries. DHIS is now in various stages of adaptation, testing and implementation in a number of other countries. A major HISP objective is to build a strong network of Open Source Software development between developing countries. Vietnam will be an important contributor to this network.

The core research and development and 'networking' activities in HISP are funded through the Norwegian Government (NUFU/NORAD). In each country participating in HISP additional funding for development, implementation and educational programmes have been obtained from various sources such as international donors and local health authorities.

Development in HCMC and in Vietnam

Collaboration with the Vietnamese National Department of Health in the project is important and the project in HCMC aims to contribute to national development.

Signature.....Date.....
Dr. Le Truong Giang, HoChiMinh City Health Department.

Signature.....Date.....
Associate Professor Jorn Braa, Department of Informatics, University of Oslo, Norway.
Coordinator of HISP

Appendix E

Memorandum of Understanding

between

The Hue Province Health Department, Vietnam

and

The Health Information Systems Program (HISP), Department of Informatics, University of Oslo, Norway

Collaboration on Health Information Systems, Open Source Software development and capacity building in Hue province

Agreement

This is a Memorandum of Understanding (MoU) between the Hue Province Health Department and HISP, University of Oslo, to collaborate on developing and implementing a district based Health Information System (HIS) in Hue Province.

TMA Solutions, Ho Chi Minh City, and Huesoft, Hue are HISP partners in the project.

The project in Hue Province will be carried out in collaboration with a similar project in Ho Chi Minh City. The project in Hue Province aims to contribute to national development through collaboration with the Vietnam's Ministry of Health.

The Open Source District Health Information Software (DHIS), developed by HISP in South Africa, will be adapted and customised according to the needs and requirements of the Hue Province. The DHIS software will be implemented in all 9 district offices and in the Hue Province Health Department. The system will capture, manage and provide analysis and reports from the data reported routinely by the wards and health units to the districts. The data is reported on paper formats from the wards and health units to the district offices where it is entered in the DHIS software. From the district the data is reported to the Hue Province Health Department on electronic formats using e-mail. Data can also be reported using discs. At the Hue Provincial Department of Health the provincial database will be maintained.

The project will revise the reporting forms and integrate the information between all health programs. Today the health units are reporting similar data to several offices at district level. The aim is to integrate this fragmented reporting structure by creating a unified and integrated district database.

In addition to the routine health data the databases at district and province levels will also contain other types of data such as population and census data, and data on infrastructure and personnel.

The system is flexible and extendable. When more health units (e.g. hospitals) get computers, the software can also be implemented and used locally, and report on electronic format to the district.

The DHIS software is a tool for health managers and workers to analyse their own data and customise reports so that information can be used for planning, monitoring, management and general support of the health services.

Project organisation and responsibilities

The project will be based at the Hue Province Health Department where 3 staff members will be allocated to work in the project. Duong Phan Bich Hai (engineer) will be responsible at the Hue Province. In addition 2 staff members from health management: the Mother and Child Health and Preventative Health programmes will be members of the team. Integration of the information from all health programs is a priority. In each district a team of 2-3 people will be formed, one person responsible for statistics and computer and one or two from health management. The province level team is responsible for training the district teams.

The Hue Province Health Department is responsible for the technical infrastructure. The project will implement the system on the computers and network that is being planned and currently implemented in the districts in Hue Province.

Revising data standards, reporting formats and routines are important parts of the software development and implementation process. HISP will assist the Hue Province Health Department in this work.

The HISP team, consisting of Huesoft, TMA Solution and the University of Oslo, will develop, adapt and maintain the DHIS software and assist the Hue Department of Health in implementing the project.

The DHIS software is developed by the international HISP network and is Open Source and provided free of costs. HISP is responsible for the software and its implementation and will assist in the training and facilitation.

Training

Training and capacity development are critical components of the implementation and need to be carried out at three levels:

- a) The Hue Province Health Department IT unit needs to be able to run, maintain and “trouble shoot” the system once it is implemented. This capacity will be developed by ensuring strong participation from the Hue Province Health Department in all stages of software adaptation and implementation.
- b) Training of staff responsible for the system at district level. A minimum of two people from each district needs to undergo training in basic system running and maintenance as well as in managing the information, making reports etc.
- c) In addition to the basic technical capacity to run the system training will also need to address analysis and use of information for management and health services delivery.

Project plan

The project will be implemented in 3 phases. At the end of each phase a more detailed plan for the next phase will be developed.

Phase 1: Pilot. 20 October 2004 – February 2005

Define and set up database based on routine reporting formats:

Revise the data sets to be used in the first database version

Organise the population / demographic data to be included in the database

Identify the key indicators to be included in the database

Define the key reports to be produced by the system

Implement the system in the Hue Province Health Department, Hue City and Huong Thuy District

Phase 2: Implementation. March – December 2005.

Implement the system in the remaining 7 Districts of Hue Province. Train all district teams.

Based on the experienced gained the software will be further developed on a continuous basis.

The aim is to get the data collection and reporting part of the system working in all districts at the end of this phase.

Phase 3: Consolidate the system and improve the use of information. January – December 2006.

This phase will focus on analysis and use of information for management and health services delivery. Health management at district and province level will be trained on how they can use the system to analyse data and make customised reports.

The staff responsible for the system in the district will be trained on analysing data and making reports.

Background: the Health Information Systems Programme (HISP)

HISP is an international research and development network. Starting in South Africa in 1994, HISP has since 1999 developed into an international network including Mozambique, Malawi, Tanzania, India and Ethiopia. Vietnam is now being included as a partner in the HISP network.

The Open Source DHIS software was first developed in South Africa and has been implemented in all districts and hospitals in that country since 1999. DHIS is now in various stages of adaptation, testing and implementation in a number of other countries. A major HISP objective is to build a strong network of Open Source Software development between developing countries. Vietnam will be an important contributor to this network.

The core research and development and ‘networking’ activities in HISP are funded through the Norwegian Government. In each country participating in HISP additional funding for development, implementation and educational programmes have been obtained from various sources such as international donors and local health authorities.

Signature.....Date.....

Dr. Nguyen Duc Hue, Director, Hue Province Health Department

Signature.....Date.....

Associate Professor Jorn Braa, Department of Informatics, University of Oslo, Norway.
Coordinator of HISP